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CLAIMS

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(57) [Claim(s)]

[Claim 1] In the assessment approach of the semi-conductor film on a substrate, while investigating beforehand a response with the minimal value and the diameter of crystal grain at the time of the primary rate of change of the reflection factor curve of the light in the light field of two or more semi-conductor film The reflection factor of the light in said light field of the semi-conductor film which should be evaluated is measured. The assessment approach of the semi-conductor film characterized by determining the diameter of crystal grain of said semi-conductor film which should be evaluated by collating with a response with two or more minimal value and the diameter of crystal grain which calculated the minimal value of the primary rate of change of the reflection factor curve, and investigated this minimal value beforehand.

[Claim 2] It is the assessment approach of the semi-conductor film according to claim 1 characterized by being wavelength with said wavelength nearest to [said reflection factor is a reflection factor of the light which carried out incidence at right angles to said semi-conductor film, and said minimal value is the value of the primary rate of change in the wavelength which changes locally the inclination of the reflection factor curve to said wavelength, or a value in said wavelength and the wavelength in which primary rate-of-change curves of a reflection factor form a trough, and] 500nm in said light field.

[Claim 3] Said semi-conductor film is the assessment approach of the semi-conductor film according to claim 1 or 2 characterized by being the semi-conductor film which became polycrystal-ized polish recon by laser annealing.

[Claim 4] The Mitsuteru gunner stage for assessment which irradiates the light for assessment at said semi-conductor film in the assessment equipment of the semi-conductor film by which the

semi-conductor film on a substrate is evaluated, A reflected light detection means to detect the reflected light from said semi-conductor film of said light for assessment, An operation means to compute the minimal value of the primary rate of change of the reflection factor curve of the light in the light field of said semi-conductor film by calculating the information from said reflected light detection means, The storage means which said minimal value and the diameter value of crystal grain were made to correspond, and held them about two or more semi-conductor film of the same kind beforehand, Assessment equipment of the semi-conductor film characterized by having an assessment means to choose from said storage means the diameter value [/ based on the minimal value computed with said operation means] of crystal grain, and to determine the diameter value of crystal grain of said semi-conductor film.
[Claim 5] Said operation means computes the minimal value of the primary rate of change of the reflection factor curve of the light in the light field of said semi-conductor film based on the information from said reflected light detection means. Said storage means Assessment equipment of the semi-conductor film according to claim 4 characterized by what the minimal value and the diameter value of crystal grain at the time of the primary rate of change of the reflection factor curve of the light in said light field are made to correspond, and are beforehand held for about two or more semi-conductor film of the same kind.
[Claim 6] Said reflection factor is a reflection factor of the light which carried out incidence at right angles to said semi-conductor film. Said minimal value The value of the primary rate of change in the point which changes locally the inclination of the reflection factor curve to said wavelength, Or it is assessment equipment of the semi-conductor film according to claim 4 or 5 characterized by being wavelength with said wavelength nearest to [are a value in the point that primary rate-of-change curves of said wavelength and reflection factor form a trough, and] 500nm in said light field.
[Claim 7] Said semi-conductor film is assessment equipment of the semi-conductor film given in either of claim 4 to claims 6 characterized by being the semi-conductor film which became polycrystal-ized polish recon by laser annealing.
[Claim 8] In the formation approach of the semi-conductor film on a substrate, a response with the minimal value and the diameter of crystal grain at the time of the primary rate of change of the reflection factor curve of the light in the light field of two or more semi-conductor film is investigated beforehand. While setting up the minimal value used as the threshold for obtaining

the desired diameter of crystal grain based on this The formation approach of the semi-conductor film characterized by calculating said minimal value of the primary rate of change of the reflection factor curve of the light in said light field of the formed semi-conductor film after forming the semi-conductor film, comparing said threshold for this minimal value, and judging the quality of said formed semi-conductor film.

[Claim 9] In the formation approach of the semi-conductor film on a substrate, a response with the minimal value and the diameter of crystal grain at the time of the primary rate of change of the reflection factor curve of the light in the light field of two or more semi-conductor film is investigated beforehand. The process which sets up beforehand the minimal value used as the threshold for obtaining the desired diameter of crystal grain based on this, The process which forms the amorphous semiconductor film, and the process which gives laser annealing to the formed amorphous semiconductor film, and is crystallized on it, The formation approach of the semi-conductor film characterized by having the process which calculates said minimal value of the primary rate of change of the reflection factor curve of the light in said light field of this crystallized semi-conductor film, and judges the quality of said formed semi-conductor film for this minimal value as compared with said threshold.

[Claim 10] Said reflection factor is a reflection factor of the light which carried out incidence at right angles to said semi-conductor film. Said minimal value The value of the primary rate of change in the wavelength which changes locally the inclination of the reflection factor curve to said wavelength, Or it is the formation approach of the semi-conductor film according to claim 8 or 9 characterized by being wavelength with said wavelength nearest to [are a value in said wavelength and the wavelength in which primary rate-of-change curves of a reflection factor form a trough, and] 500nm in a light field.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] About the assessment approach of the semi-conductor film created on the substrate, assessment equipment, and the formation approach, this invention is deducing the diameter of crystal grain of the semi-conductor film by optical observation especially, and relates to the assessment approach of the semi-conductor film which enabled in-line-ization, assessment equipment, and the formation approach.

[0002]
[Description of the Prior Art] By using on a substrate the technique which creates the semi-conductor film, the thin film electric field effect mold transistor (TFT:Thin Film Transistor) used as the switching element of the matrix display section is made to one side of the substrate of the couple which raises the degree of integration of an integrated circuit, and attains large capacity-ization, or pinched liquid crystal in between, and development of mass-producing the liquid crystal display (LCD:Liquid Crystal Display) of the active-matrix mold which makes a high definition animation display possible is performed to it.
[0003] If TFT as can show the property near MOSFET especially produced by the silicon substrate can be formed on an insulating substrate, it becomes possible not only the switching element of the matrix display section of LCD but to make the circumference actuation circuit for forming CMOS on the outskirts and supplying a desired actuation signal level to the matrix display section in one, and the so-called mass production driver built-in [LCD] can be performed.
[0004] Since it becomes unnecessary to perform external [of a driver component] to a liquid crystal panel, the cutback of processes and narrow picture frame-ization of driver built-in [LCD] are attained. Especially, as for narrow-picture-frame-izing, the miniaturization of the product itself is attained in the application of a Personal Digital Assistant in recent years or the monitor of a handicap video camera. As one of the important technical problems in such utilization driver built-in [LCD], the good semi-conductor film may be created at the temperature in the heat-resistant critical range of a substrate on transparence insulating substrates, such as glass. Conventionally, forming TFT on a glass substrate was comparatively performed by low temperature by the 300 to about 400 degrees C thing for which amorphous substance-like a semi-conductor layer, especially an amorphous silicon (a-Si) are created. However, even if on resistance was high and could apply to the switching device of the matrix display section, by the time such a-SiTFT made it possible to constitute the driver section as which high-speed actuation is required from it, it did not result.
[0005] On the other hand, TFT applicable also to the driver section can be formed by using for a channel layer the polycrystal semi-conductor with which the single crystal grain (grain) of a large number with the particle size of hundreds of A to thousands of A exists in the form where it contacted mutually. CMOS with sufficient rate to obtain dozens to about [hundreds of cm]

2/V.s, and for mobility be larger than a-Si double figures, especially polycrystalline silicon (p-Si), i.e., polish recon, and constitute the driver of LCD is formed.

[0006] In order to create such driver built-in p-SiTFTLCD, it has been the biggest technical problem to form good p-Si of membraneous quality on a glass substrate. Usually, p-Si is formed by the approach of forming membranes directly with the solid phase grown method (SPC) to which crystallization is urged by heat-treating to a-Si formed on the substrate, or reduced pressure CVD. Each of these membrane formation approaches is processings in an elevated temperature of 700 to about 900 degrees C, and the manufacture process of p-SiTFTLCD including such an elevated-temperature process is called an elevated-temperature process. In the elevated-temperature process, expensive substrates, such as heat-resistant high quartz glass, required as a substrate, and cost was high.

[0007] For this reason, for some time, the applicant has been developing the approach of the highest also making temperature of a process about 600 degrees C or less, and enabling adoption of a cheap alkali-free-glass substrate etc. as a substrate, in order to lower cost. The manufacture process of p-SiTFTLCD which suppressed such all processes below to the critical temperature of the thermal resistance of a substrate is called a low-temperature process.

[0008] A low-temperature process is giving an excimer laser to a-Si, and became possible by excimer laser annealing (ELA) which stimulates crystallization and creates p-Si. Although an excimer laser is ultraviolet radiation generated in case the excimer made into the excitation state returns to a ground state, by ELA, it processes the configuration of a laser beam according to predetermined optical system, and is irradiated at the non-processing film. Thereby, heat energy is given especially on the surface of a-Si, at the temperature below the heat-resistant critical temperature of a substrate, crystallization is performed and p-Si is formed.

[0009]

[Problem(s) to be Solved by the Invention] In ELA, it has been main technical problems to solve the problem of the optimal setting out of the laser power and dispersion of exposure laser energy. As the relation between exposure laser energy and the diameter of crystal grain of p-Si (grain size) is shown in drawing 13 , grain size also becomes large as energy imparted becomes large, but if a certain point exceeds a certain point, grain size will become small rapidly and it will become microcrystal-ization, i.e., micro crystal. Therefore, in order to obtain more than grain size (GM) big enough, the power of the laser light source must be set up the optimal between

Minimum Ed and an upper limit Eu, and it is necessary to always manage ELA based on the relation of drawing 13 .

[0010] especially -- degradation of a laser medium -- following -- power setting out of equipment -- actually -- a ratio -- if a gap with the effective energy irradiated by the processing film becomes large -- drawing 13 -- following -- the grain size of p-Si -- desired value -- small -- **********. Moreover, in ELA equipment, the laser light emitted in the source of laser oscillation passes long-distance optical system, in order to operate orthopedically in the configuration of having been suitable for predetermined laser annealing and that it does not irradiate, but if optical system is polluted in this case even when it is slight by moisture, a foreign matter, etc., it will cause lowering of effective energy too.

[0011] Furthermore, dispersion in effective exposure energy also poses a problem. That is, if dispersion in exposure reinforcement has arisen in the exposure field of a laser beam, it will pose a problem that grain size does not become large enough in the field corresponding to the part from which exposure energy separated from the optimal range of drawing 13 . As the assessment approach of the grain size of conventional p-Si, although there is SEKOETCHI, the substrate which evaluated the film by this approach cannot be used as a product, but can only perform guessing assessment of other substrates.

[0012] This inventions are the approach an in-line monitor estimates the p-Si film of this ** directly for the purpose of solving the problem to which it comes from exposure laser energy varying, and a thing which offers the formation approach and formation equipment further.

[0013]

[Means for Solving the Problem] This invention is the configuration of being made in order to attain this object, and deducing the diameter of crystal grain of the semi-conductor film based on the reflection factor of the light in the light field of the semi-conductor film. Furthermore, in the appraisal method method of the semi-conductor film on a substrate, while investigating beforehand a response with the minimal value and the diameter of crystal grain at the time of the primary rate of change of the reflection factor curve of the light in the light field of two or more semi-conductor film It is the configuration of determining the diameter of crystal grain of said semi-conductor film which should be evaluated, by measuring the reflection factor of the light in said light field of the semi-conductor film which should be evaluated, calculating said minimal value of the reflection factor curve, and collating this minimal value with a response with said

two or more minimal value and diameter of crystal grain which were investigated beforehand. Thereby, the diameter of crystal grain can be evaluated, without destroying the semi-conductor film. [0014] Moreover, this invention is set to the assessment equipment of the semi-conductor film by which the semi-conductor film on a substrate is evaluated. The assessment Mitsuteru gunner stage which irradiates the light for assessment at said semi-conductor film, and a reflected light detection means to detect the reflected light from said semi-conductor film of said light for assessment, An operation means to compute the minimal value of the primary rate of change of the reflection factor curve of the light in the light field of said semi-conductor film by calculating the information from said reflected light detection means, It is the configuration of having the storage means which said minimal value and the diameter value of crystal grain were made corresponding, and held them about two or more semi-conductor film of the same kind beforehand, and an assessment means to choose from said storage means the diameter value [/ based on the minimal value computed with said operation means] of crystal grain, and to determine the diameter value of crystal grain of said semi-conductor film.

[0015] Said especially operation means computes the minimal value of the primary rate of change of the reflection factor curve of the light in the light field of said semi-conductor film based on the information from said reflected light detection means, and said storage means is a configuration which the minimal value and the diameter value of crystal grain at the time of the primary rate of change of the reflection factor curve of the light in said light field are made to correspond about two or more semi-conductor film of the same kind beforehand, and is held. Since the diameter of crystal grain can be evaluated by this, without destroying the semi-conductor film, the diameter of crystal grain can be investigated in a manufacture process. [0016] Moreover, in the formation approach of the semi-conductor film on a substrate, a response with the minimal value and the diameter of crystal grain at the time of the primary rate of change of the reflection factor curve of the light in the light field of two or more semi-conductor film is investigated beforehand. While setting up the minimal value used as the threshold for obtaining the desired diameter of crystal grain based on this It is the configuration of calculating said minimal value of the primary rate of change of the reflection factor curve of the light in said light field of the semi-conductor film after forming the semi-conductor film, comparing said threshold for this minimal value, and judging the quality of said formed semi-conductor film.

[0017] Furthermore, in the formation approach of the semi-conductor film on a substrate, a

response with the minimal value and the diameter of crystal grain at the time of the primary rate of change of the reflection factor curve of the light in the light field of two or more semi-conductor film is investigated beforehand. The process which sets up beforehand the minimal value used as the threshold for obtaining the desired diameter of crystal grain based on this, The process which forms the amorphous semiconductor film, and the process which gives laser annealing to the formed amorphous semiconductor film, and is crystallized on it, It is the configuration of having the process which calculates said minimal value of the primary rate of change of the reflection factor curve of the light in said light field of this crystallized semi-conductor film, and judges the quality of said formed semi-conductor film for this minimal value as compared with said threshold.

[0018] Since the diameter of crystal grain can be evaluated by this, without destroying the semi-conductor film, in the middle of a manufacture process, a defective can be removed and cost is reduced.

[0019] Drawing 1 to drawing 4 is related curvilinear drawing which measured the wavelength dependency (phase comparison) of the reflection factor of the p-Si film formed by giving ELA to the a-Si film. As an optical exposure and lighting equipment, the multichannel spectrometry machine made from the Otsuka electron was used. Moreover, an optical exposure and the reflected light went perpendicularly to the object film. In addition, the light of a 400nm - 750nm light field was used for the exposure. When ELA laser power of drawing 1 is 520mJ(s), drawing 2 is [540mJ(s) and drawing 4 of 530mJ(s) and drawing 3] 550mJ(s) similarly. By comparing these drawings shows the following things. That is, the related curve is presenting the characteristic configuration near the wavelength of 500nm, and the singularity itself is further dependent also on laser power. Especially, in drawing 1 and drawing 2 , it is a trough. such change of the configuration of the reflection factor curve depending on laser power originates in change of the grain size of the p-Si film -- it thinks.

[0020] Then, the applicant differentiated the reflection factor curve and searched for primary rate of change. Drawing 5 to drawing 8 is the wavelength dependency curve of the primary rate of change of the reflection factor curve of drawing 1 to drawing 4 respectively. The deflection of a rate-of-change curve is large in the form where the singular part of a reflection factor curve was emphasized in near 500nm like drawing 4 from drawing 1 . namely, the singular part of the reflection factor curve in drawing 4 from drawing 1 -- in more detail in the field near [where

wavelength becomes large / where it is alike, and it follows and a reflection factor also becomes high] 500nm, the inclination of a reflection factor curve has changed locally -- further There is a place which falls and serves as a trough and the relation of such a wavelength-reflection factor is clearly expressed as the minimum depth as shown by the arrow head in the trough of a rate-of-change curve in drawing 8 from drawing 5 . It has this minimal value and is made to represent with this invention as an optical value which is a value of a proper when ELA is performed under each conditions.

[0021] Drawing 9 is drawing which investigated the relation between the optical value acquired by doing in this way, and the grain size obtained by surveying by SEKOETCHI etc. on the actual p-Si film at that time about many samples. A continuous line is a trend line of these relation. This shows that grain size is large, so that it will be carried out the more if the singular part of the reflection factor curve of drawing 4 is eased from drawing 1 the more an optical value becomes large namely. That is, in these condition range, grain size is changing to the linear to an optical value. Therefore, grain size can be deduced by investigating the rate of change of a reflection factor.

[0022] Although the mechanism does not have such a clear wavelength dependency of a reflection factor or its rate of change about a unique property being shown in a specific wavelength field, depending on whenever [crystal order], the superiority or inferiority of an echo and scattered reflection change, and that in which it appears notably in an above-mentioned wavelength region especially is conjectured. Therefore, the diameter of crystal grain can be deduced from investigating such optical property in inverse operation.

[0023] Here, I hear that the relation between an optical value and laser energy (grain size) has the description as shown in drawing 10 , and having been traced still more nearly experientially has it. That is, in a certain energy field, an optical value turns into the minimum value and it has relation in which an optical value rises symmetrically on the both sides. And the energy density which takes the minimum value of such an optical value experimentally is from 300 mJ/cm2 to 350 mJ/cm2 generally, and when the laser power in ELA considers that fine adjustment in the range of 400 mJ/cm2 to about two 500 mJ/cm is demanded for an energy density, it turns out that the relation between an optical value and laser power, i.e., grain size, presents a linear configuration mostly.

[0024] Drawing 11 is the block diagram of the assessment equipment concerning the gestalt of

operation of this invention. It is the processed substrate with which the semi-conductor film with which operation part and (2) should evaluate (1) and a detecting element and (5) should evaluate the storage section and (3) was formed. As for a detecting element (3), a light emitting device and lighting components, such as a halogen lamp, constitute the coaxial fiber. ELA is given, a processed substrate (5) is crystallized by a-Si formed on the insulating substrate, and p-Si is formed. A detecting element (3) detects that reflected light, and investigates the spectral characteristic while it irradiates the light for detection at this processed substrate (5). This spectral characteristic information is sent to operation part (1). In operation part (1), the wavelength dependency of the reflection factor shown in drawing 4 from drawing 1 is computed, the primary rate of change of the reflection factor shown in drawing 8 from drawing 5 is searched for, further, the minimal value is investigated and an optical value is determined after this. This optical value is sent to the storage section (2). The optical value shown in drawing 9 and the grain size at that time correspond, and are held at the storage section (2). The storage section (2) is the nonvolatile memory by which the value of the grain size which made information based on an optical value the address was held. Therefore, the address is generated based on the optical value sent from operation part (1), and reading appearance of the value of grain size is carried out. Thus, the obtained grain size is determined as grain size of the processed substrate (5). Dispersion in the exposure field of ELA energy is manageable by performing measurement of such grain size by two or more points on a processed substrate (5). Moreover, according to the property of ELA equipment, and the time of equipment, the information held at the storage section (2) can be rewritten, or can also respond also to long-term condition fluctuation by exchanging memory etc.

[0025] Assessment of the p-Si film in such this invention is performed by measurement of the rate of a light reflex, i.e., lighting of a suitable optical exposure and its reflected light. Therefore, in-line monitoring can become possible, the grain size measurement process concerning this invention can be installed immediately after the formation process of the p-Si film, and ELA can be managed. Drawing 12 is assessment equipment introduced into a manufacture process. (1), (3), and (5) are the same operation part as drawing 11 , a detecting element, and a processed substrate respectively. (4) is the judgment section. The optical value corresponding to the upper limit of the tolerance of the grain size of target p-Si and the optical value corresponding to a minimum are set to the judgment section (4). The optical value sent from operation part (1) is compared

with the optical value of these upper limits and a minimum, it is investigated whether the grain size of the processed substrate (5) of this ** is in tolerance, and the quality of the processed substrate (5) is judged. When it judges that a processed substrate (5) is poor, as for the processed substrate (5), migration at degree process is forbidden.

[0026] By thus, the thing for which the assessment process of this invention is installed after an ELA process Measure the grain size just behind ELA and laser radiation energy changes for some reasons [exhausting / contamination of moisture, a foreign matter, and optical system, / of the laser light source]. When grain size does not become large enough, or it stops and cancels ** and manufacture, delivery and the p-Si film are removed at the etching process of the p-Si film, and measures, such as redoing from a membrane formation process again, are taken. Furthermore, by unifying the assessment process of ELA and this invention, the p-Si film is evaluated on a simultaneous target, performing laser radiation, and ELA while always adjusting laser power the optimal becomes possible by feeding back to ELA.

[0027]

[Effect of the Invention] By this invention, since insertion to a production process of the assessment process of the diameter of crystal grain of the semi-conductor film was attained, management of a semi-conductor film formation process can always be performed. Thereby, when the membraneous quality of the semi-conductor film immediately after formation comes outside tolerance, ** and manufacture can be stopped and a defective can be discovered in an early phase. For this reason, excessive cost is reduced and the yield improves. Moreover, film assessment is performed in parallel with a production process, and since it is always finely tuned by the optimal conditions by reflecting this in a semi-conductor film formation process, a semiconductor device with a good property is manufactured.

TECHNICAL FIELD

[Field of the Invention] About the assessment approach of the semi-conductor film created on the substrate, assessment equipment, and the formation approach, this invention is deducing the diameter of crystal grain of the semi-conductor film by optical observation especially, and relates to the assessment approach of the semi-conductor film which enabled in-line-ization, assessment equipment, and the formation approach.

PRIOR ART

[Description of the Prior Art] By using on a substrate the technique which creates the semi-conductor film, the thin film electric field effect mold transistor (TFT:Thin Film Transistor) used as the switching element of the matrix display section is made to one side of the substrate of the couple which raises the degree of integration of an integrated circuit, and attains large capacity-ization, or pinched liquid crystal in between, and development of mass-producing the liquid crystal display (LCD:Liquid Crystal Display) of the active-matrix mold which makes a high definition animation display possible is performed to it.

[0003] If TFT as can show the property near MOSFET especially produced by the silicon substrate can be formed on an insulating substrate, it becomes possible not only the switching element of the matrix display section of LCD but to make the circumference actuation circuit for forming CMOS on the outskirts and supplying a desired actuation signal level to the matrix display section in one, and the so-called mass production driver built-in [LCD] can be performed.

[0004] Since it becomes unnecessary to perform external [of a driver component] to a liquid crystal panel, the cutback of processes and narrow picture frame-ization of driver built-in [LCD] are attained. Especially, as for narrow-picture-frame-izing, the miniaturization of the product itself is attained in the application of a Personal Digital Assistant in recent years or the monitor of a handicap video camera. As one of the important technical problems in such utilization driver built-in [LCD], the good semi-conductor film may be created at the temperature in the heat-resistant critical range of a substrate on transparence insulating substrates, such as glass. Conventionally, forming TFT on a glass substrate was comparatively performed by low temperature by the 300 to about 400 degrees C thing for which amorphous substance-like a semi-conductor layer, especially an amorphous silicon (a-Si) are created. However, even if on resistance was high and could apply to the switching device of the matrix display section, by the time such a-SiTFT made it possible to constitute the driver section as which high-speed actuation is required from it, it did not result.

[0005] On the other hand, TFT applicable also to the driver section can be formed by using for a channel layer the polycrystal semi-conductor with which the single crystal grain (grain) of a large number with the particle size of hundreds of A to thousands of A exists in the form where it contacted mutually. CMOS with sufficient rate to obtain dozens to about [hundreds of cm] 2/V.s, and for mobility be larger than a-Si double figures, especially polycrystalline silicon (p-Si),

i.e., polish recon, and constitute the driver of LCD is formed.

[0006] In order to create such driver built-in p-SiTFTLCD, it has been the biggest technical problem to form good p-Si of membraneous quality on a glass substrate. Usually, p-Si is formed by the approach of forming membranes directly with the solid phase grown method (SPC) to which crystallization is urged by heat-treating to a-Si formed on the substrate, or reduced pressure CVD. Each of these membrane formation approaches is processings in an elevated temperature of 700 to about 900 degrees C, and the manufacture process of p-SiTFTLCD including such an elevated-temperature process is called an elevated-temperature process. In the elevated-temperature process, expensive substrates, such as heat-resistant high quartz glass, required as a substrate, and cost was high.

[0007] For this reason, for some time, the applicant has been developing the approach of the highest also making temperature of a process about 600 degrees C or less, and enabling adoption of a cheap alkali-free-glass substrate etc. as a substrate, in order to lower cost. The manufacture process of p-SiTFTLCD which suppressed such all processes below to the critical temperature of the thermal resistance of a substrate is called a low-temperature process.

[0008] A low-temperature process is giving an excimer laser to a-Si, and became possible by excimer laser annealing (ELA) which stimulates crystallization and creates p-Si. Although an excimer laser is ultraviolet radiation generated in case the excimer made into the excitation state returns to a ground state, by ELA, it processes the configuration of a laser beam according to predetermined optical system, and is irradiated at the non-processing film. Thereby, heat energy is given especially on the surface of a-Si, at the temperature below the heat-resistant critical temperature of a substrate, crystallization is performed and p-Si is formed.

EFFECT OF THE INVENTION

[Effect of the Invention] By this invention, since insertion to a production process of the assessment process of the diameter of crystal grain of the semi-conductor film was attained, management of a semi-conductor film formation process can always be performed. Thereby, when the membraneous quality of the semi-conductor film immediately after formation comes outside tolerance, ** and manufacture can be stopped and a defective can be discovered in an early phase. For this reason, excessive cost is reduced and the yield improves. Moreover, film assessment is performed in parallel with a production process, and since it is always finely tuned

by the optimal conditions by reflecting this in a semi-conductor film formation process, a semiconductor device with a good property is manufactured.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] In ELA, it has been main technical problems to solve the problem of the optimal setting out of the laser power and dispersion of exposure laser energy. As the relation between exposure laser energy and the diameter of crystal grain of p-Si (grain size) is shown in drawing 13 , grain size also becomes large as energy imparted becomes large, but if a certain point exceeds a certain point, grain size will become small rapidly and it will become microcrystal-ization, i.e., micro crystal. Therefore, in order to obtain more than grain size (GM) big enough, the power of the laser light source must be set up the optimal between Minimum Ed and an upper limit Eu, and it is necessary to always manage ELA based on the relation of drawing 13 .

[0010] especially -- degradation of a laser medium -- following -- power setting out of equipment -- actually -- a ratio -- if a gap with the effective energy irradiated by the processing film becomes large -- drawing 13 -- following -- the grain size of p-Si -- desired value -- small -- **********. Moreover, in ELA equipment, the laser light emitted in the source of laser oscillation passes long-distance optical system, in order to operate orthopedically in the configuration of having been suitable for predetermined laser annealing and that it does not irradiate, but if optical system is polluted in this case even when it is slight by moisture, a foreign matter, etc., it will cause lowering of effective energy too.

[0011] Furthermore, dispersion in effective exposure energy also poses a problem. That is, if dispersion in exposure reinforcement has arisen in the exposure field of a laser beam, it will pose a problem that grain size does not become large enough in the field corresponding to the part from which exposure energy separated from the optimal range of drawing 13 . As the assessment approach of the grain size of conventional p-Si, although there is SEKOETCHI, the substrate which evaluated the film by this approach cannot be used as a product, but can only perform guessing assessment of other substrates.

[0012] This inventions are the approach an in-line monitor estimates the p-Si film of this ** directly for the purpose of solving the problem to which it comes from exposure laser energy varying, and a thing which offers the formation approach and formation equipment further.

MEANS

[Means for Solving the Problem] This invention is the configuration of being made in order to attain this object, and deducing the diameter of crystal grain of the semi-conductor film based on the reflection factor of the light in the light field of the semi-conductor film. Furthermore, in the appraisal method method of the semi-conductor film on a substrate, while investigating beforehand a response with the minimal value and the diameter of crystal grain at the time of the primary rate of change of the reflection factor curve of the light in the light field of two or more semi-conductor film It is the configuration of determining the diameter of crystal grain of said semi-conductor film which should be evaluated, by measuring the reflection factor of the light in said light field of the semi-conductor film which should be evaluated, calculating said minimal value of the reflection factor curve, and collating this minimal value with a response with said two or more minimal value and diameter of crystal grain which were investigated beforehand. Thereby, the diameter of crystal grain can be evaluated, without destroying the semi-conductor film. [0014] Moreover, this invention is set to the assessment equipment of the semi-conductor film by which the semi-conductor film on a substrate is evaluated. The assessment Mitsuteru gunner stage which irradiates the light for assessment at said semi-conductor film, and a reflected light detection means to detect the reflected light from said semi-conductor film of said light for assessment, An operation means to compute the minimal value of the primary rate of change of the reflection factor curve of the light in the light field of said semi-conductor film by calculating the information from said reflected light detection means, It is the configuration of having the storage means which said minimal value and the diameter value of crystal grain were made corresponding, and held them about two or more semi-conductor film of the same kind beforehand, and an assessment means to choose from said storage means the diameter value [/ based on the minimal value computed with said operation means] of crystal grain, and to determine the diameter value of crystal grain of said semi-conductor film.

[0015] Said especially operation means computes the minimal value of the primary rate of change of the reflection factor curve of the light in the light field of said semi-conductor film based on the information from said reflected light detection means, and said storage means is a configuration which the minimal value and the diameter value of crystal grain at the time of the primary rate of change of the reflection factor curve of the light in said light field are made to correspond about two or more semi-conductor film of the same kind beforehand, and is held.

Since the diameter of crystal grain can be evaluated by this, without destroying the semi-conductor film, the diameter of crystal grain can be investigated in a manufacture process. [0016] Moreover, in the formation approach of the semi-conductor film on a substrate, a response with the minimal value and the diameter of crystal grain at the time of the primary rate of change of the reflection factor curve of the light in the light field of two or more semi-conductor film is investigated beforehand. While setting up the minimal value used as the threshold for obtaining the desired diameter of crystal grain based on this It is the configuration of calculating said minimal value of the primary rate of change of the reflection factor curve of the light in said light field of the semi-conductor film after forming the semi-conductor film, comparing said threshold for this minimal value, and judging the quality of said formed semi-conductor film.

[0017] Furthermore, in the formation approach of the semi-conductor film on a substrate, a response with the minimal value and the diameter of crystal grain at the time of the primary rate of change of the reflection factor curve of the light in the light field of two or more semi-conductor film is investigated beforehand. The process which sets up beforehand the minimal value used as the threshold for obtaining the desired diameter of crystal grain based on this, The process which forms the amorphous semiconductor film, and the process which gives laser annealing to the formed amorphous semiconductor film, and is crystallized on it, It is the configuration of having the process which calculates said minimal value of the primary rate of change of the reflection factor curve of the light in said light field of this crystallized semi-conductor film, and judges the quality of said formed semi-conductor film for this minimal value as compared with said threshold.

[0018] Since the diameter of crystal grain can be evaluated by this, without destroying the semi-conductor film, in the middle of a manufacture process, a defective can be removed and cost is reduced.

[0019] Drawing 1 to drawing 4 is related curvilinear drawing which measured the wavelength dependency (phase comparison) of the reflection factor of the p-Si film formed by giving ELA to the a-Si film. As an optical exposure and lighting equipment, the multichannel spectrometry machine made from the Otsuka electron was used. Moreover, an optical exposure and the reflected light went perpendicularly to the object film. In addition, the light of a 400nm - 750nm light field was used for the exposure. When ELA laser power of drawing 1 is 520mJ(s), drawing 2 is [540mJ(s) and drawing 4 of 530mJ(s) and drawing 3] 550mJ(s) similarly. By comparing

these drawings shows the following things. That is, the related curve is presenting the characteristic configuration near the wavelength of 500nm, and the singularity itself is further dependent also on laser power. Especially, in drawing 1 and drawing 2 , it is a trough. such change of the configuration of the reflection factor curve depending on laser power originates in change of the grain size of the p-Si film -- it thinks.

[0020] Then, the applicant differentiated the reflection factor curve and searched for primary rate of change. Drawing 5 to drawing 8 is the wavelength dependency curve of the primary rate of change of the reflection factor curve of drawing 1 to drawing 4 respectively. The deflection of a rate-of-change curve is large in the form where the singular part of a reflection factor curve was emphasized in near 500nm like drawing 4 from drawing 1 . namely, the singular part of the reflection factor curve in drawing 4 from drawing 1 -- in more detail in the field near [where wavelength becomes large / where it is alike, and it follows and a reflection factor also becomes high] 500nm, the inclination of a reflection factor curve has changed locally -- further There is a place which falls and serves as a trough and the relation of such a wavelength-reflection factor is clearly expressed as the minimum depth as shown by the arrow head in the trough of a rate-of-change curve in drawing 8 from drawing 5 . It has this minimal value and is made to represent with this invention as an optical value which is a value of a proper when ELA is performed under each conditions.

[0021] Drawing 9 is drawing which investigated the relation between the optical value acquired by doing in this way, and the grain size obtained by surveying by SEKOETCHI etc. on the actual p-Si film at that time about many samples. A continuous line is a trend line of these relation. This shows that grain size is large, so that it will be carried out the more if the singular part of the reflection factor curve of drawing 4 is eased from drawing 1 the more an optical value becomes large namely. That is, in these condition range, grain size is changing to the linear to an optical value. Therefore, grain size can be deduced by investigating the rate of change of a reflection factor.

[0022] Although the mechanism does not have such a clear wavelength dependency of a reflection factor or its rate of change about a unique property being shown in a specific wavelength field, depending on whenever [crystal order], the superiority or inferiority of an echo and scattered reflection change, and that in which it appears notably in an above-mentioned wavelength region especially is conjectured. Therefore, the diameter of crystal grain can be

deduced from investigating such optical property in inverse operation.

[0023] Here, I hear that the relation between an optical value and laser energy (grain size) has the description as shown in drawing 10 , and having been traced still more nearly experientially has it. That is, in a certain energy field, an optical value turns into the minimum value and it has relation in which an optical value rises symmetrically on the both sides. And the energy density which takes the minimum value of such an optical value experimentally is from 300 mJ/cm2 to 350 mJ/cm2 generally, and when the laser power in ELA considers that fine adjustment in the range of 400 mJ/cm2 to about two 500 mJ/cm is demanded for an energy density, it turns out that the relation between an optical value and laser power, i.e., grain size, presents a linear configuration mostly.

[0024] Drawing 11 is the block diagram of the assessment equipment concerning the gestalt of operation of this invention. It is the processed substrate with which the semi-conductor film with which operation part and (2) should evaluate (1) and a detecting element and (5) should evaluate the storage section and (3) was formed. As for a detecting element (3), a light emitting device and lighting components, such as a halogen lamp, constitute the coaxial fiber. ELA is given, a processed substrate (5) is crystallized by a-Si formed on the insulating substrate, and p-Si is formed. A detecting element (3) detects that reflected light, and investigates the spectral characteristic while it irradiates the light for detection at this processed substrate (5). This spectral characteristic information is sent to operation part (1). In operation part (1), the wavelength dependency of the reflection factor shown in drawing 4 from drawing 1 is computed, the primary rate of change of the reflection factor shown in drawing 8 from drawing 5 is searched for, further, the minimal value is investigated and an optical value is determined after this. This optical value is sent to the storage section (2). The optical value shown in drawing 9 and the grain size at that time correspond, and are held at the storage section (2). The storage section (2) is the nonvolatile memory by which the value of the grain size which made information based on an optical value the address was held. Therefore, the address is generated based on the optical value sent from operation part (1), and reading appearance of the value of grain size is carried out. Thus, the obtained grain size is determined as grain size of the processed substrate (5). Dispersion in the exposure field of ELA energy is manageable by performing measurement of such grain size by two or more points on a processed substrate (5). Moreover, according to the property of ELA equipment, and the time of equipment, the information held at

the storage section (2) can be rewritten, or can also respond also to long-term condition fluctuation by exchanging memory etc.

[0025] Assessment of the p-Si film in such this invention is performed by measurement of the rate of a light reflex, i.e., lighting of a suitable optical exposure and its reflected light. Therefore, in-line monitoring can become possible, the grain size measurement process concerning this invention can be installed immediately after the formation process of the p-Si film, and ELA can be managed. Drawing 12 is assessment equipment introduced into a manufacture process. (1), (3), and (5) are the same operation part as drawing 11 , a detecting element, and a processed substrate respectively. (4) is the judgment section. The optical value corresponding to the upper limit of the tolerance of the grain size of target p-Si and the optical value corresponding to a minimum are set to the judgment section (4). The optical value sent from operation part (1) is compared with the optical value of these upper limits and a minimum, it is investigated whether the grain size of the processed substrate (5) of this ** is in tolerance, and the quality of the processed substrate (5) is judged. When it judges that a processed substrate (5) is poor, as for the processed substrate (5), migration at degree process is forbidden.

[0026] By thus, the thing for which the assessment process of this invention is installed after an ELA process Measure the grain size just behind ELA and laser radiation energy changes for some reasons [exhausting / contamination of moisture, a foreign matter, and optical system, / of the laser light source]. When grain size does not become large enough, or it stops and cancels ** and manufacture, delivery and the p-Si film are removed at the etching process of the p-Si film, and measures, such as redoing from a membrane formation process again, are taken. Furthermore, by unifying the assessment process of ELA and this invention, the p-Si film is evaluated on a simultaneous target, performing laser radiation, and ELA while always adjusting laser power the optimal becomes possible by feeding back to ELA.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is related drawing which measured the wavelength dependency of the reflection factor of the p-Si film in this invention.

[Drawing 2] It is related drawing which measured the wavelength dependency of the reflection factor of the p-Si film in this invention.

[Drawing 3] It is related drawing which measured the wavelength dependency of the reflection

factor of the p-Si film in this invention.

[Drawing 4] It is related drawing which measured the wavelength dependency of the reflection factor of the p-Si film in this invention.

[Drawing 5] It is related drawing which searched for primary rate of change from the curve of the wavelength dependency of the reflection factor in drawing 1 .

[Drawing 6] It is related drawing which searched for the primary rate of change of the curve of the wavelength dependency of the reflection factor in drawing 2 .

[Drawing 7] It is related drawing which searched for the primary rate of change of the curve of the wavelength dependency of the reflection factor in drawing 3 .

[Drawing 8] It is related drawing which searched for the primary rate of change of the curve of the wavelength dependency of the reflection factor in drawing 4 .

[Drawing 9] It is related drawing of the minimal value of primary rate of change, and the grain size of the p-Si film.

[Drawing 10] It is related drawing of laser energy and the minimal value of primary rate of change.

[Drawing 11] It is the block diagram of the assessment equipment of the semi-conductor film concerning the gestalt of operation of this invention.

[Drawing 12] It is the block diagram of the formation equipment of the semi-conductor film concerning the gestalt of operation of this invention.

[Drawing 13] It is related drawing of exposure laser energy and grain size.

[Description of Notations]

1 Operation Part

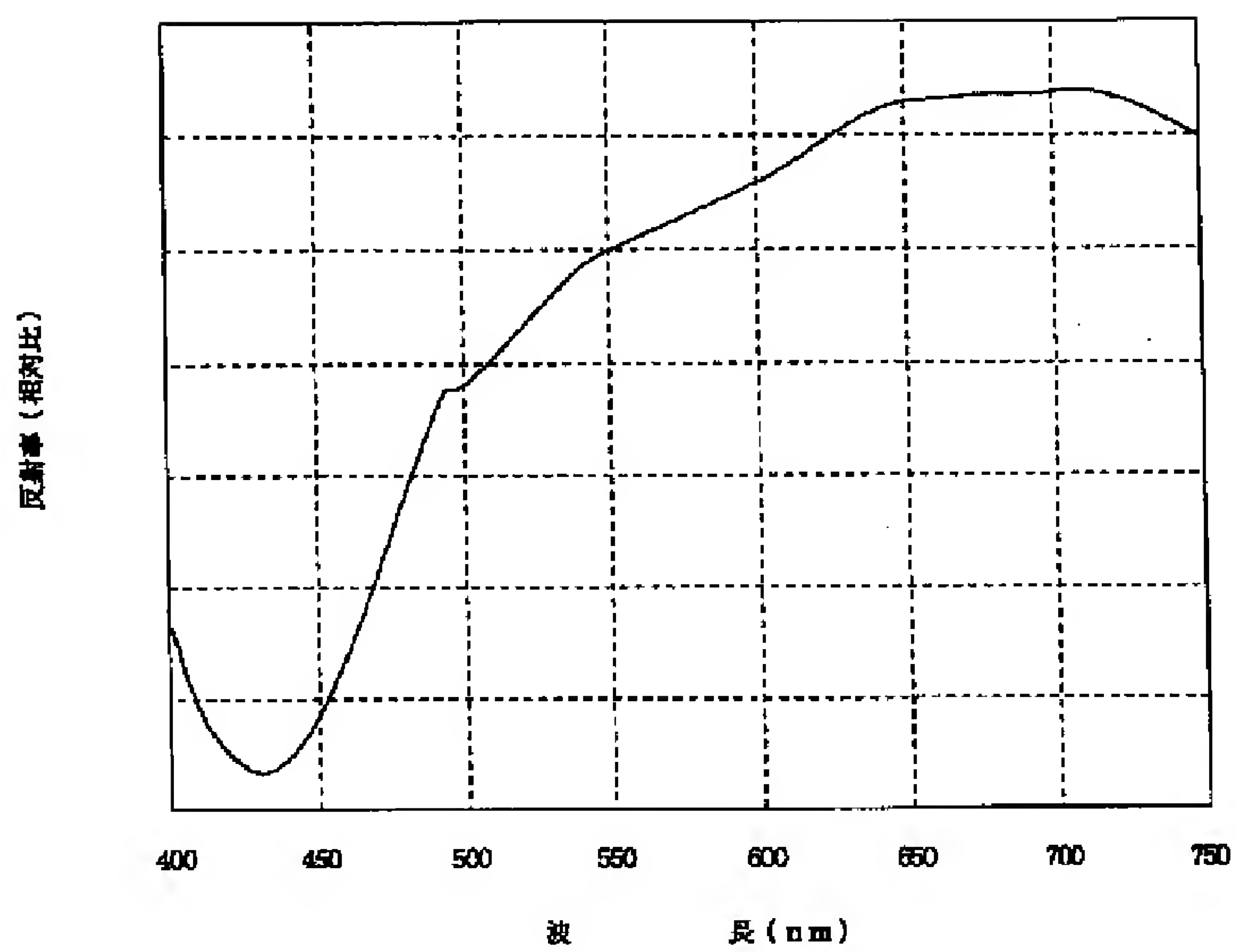
2 Storage Section

3 Detecting Element

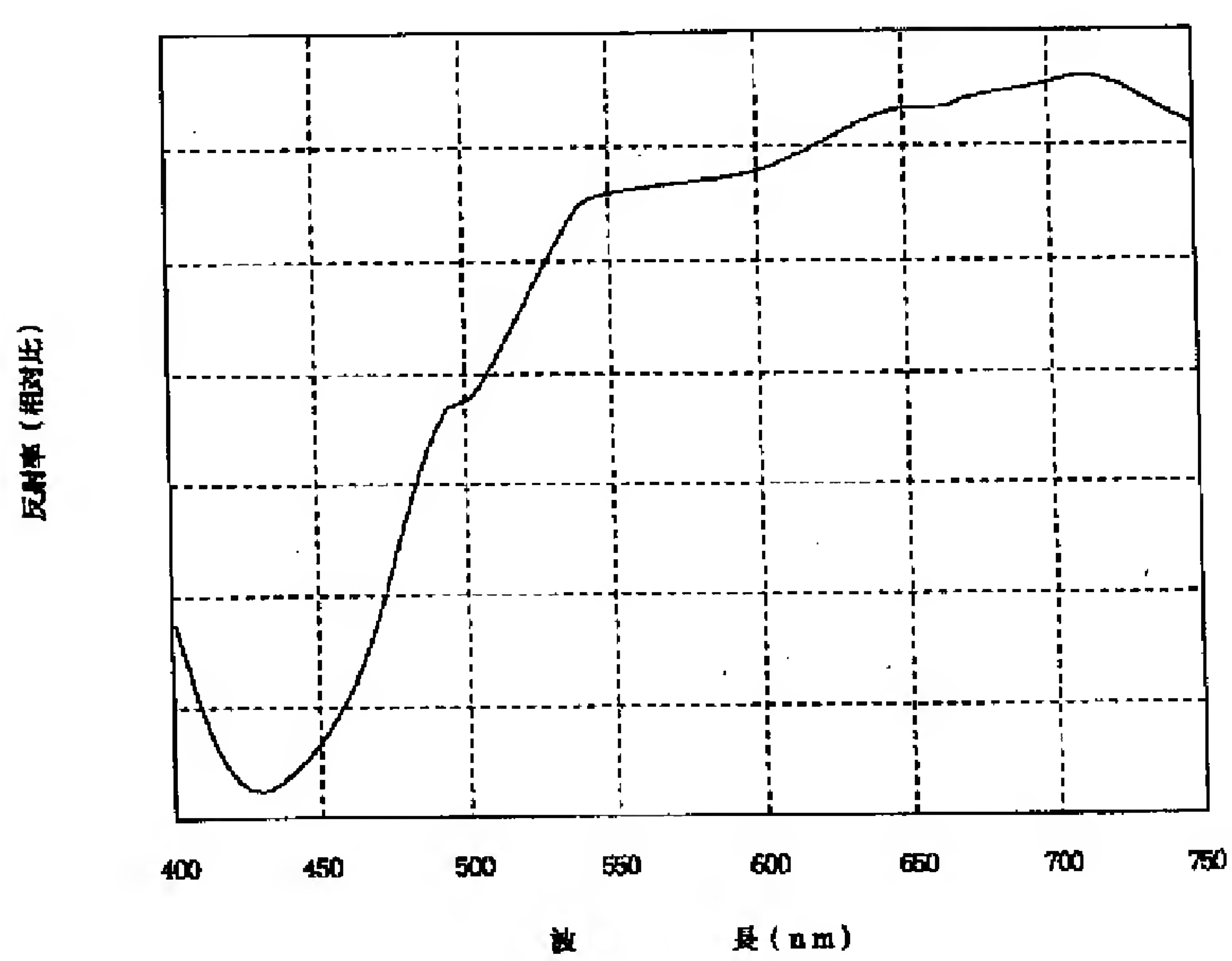
4 Judgment Section

5 Processed Substrate

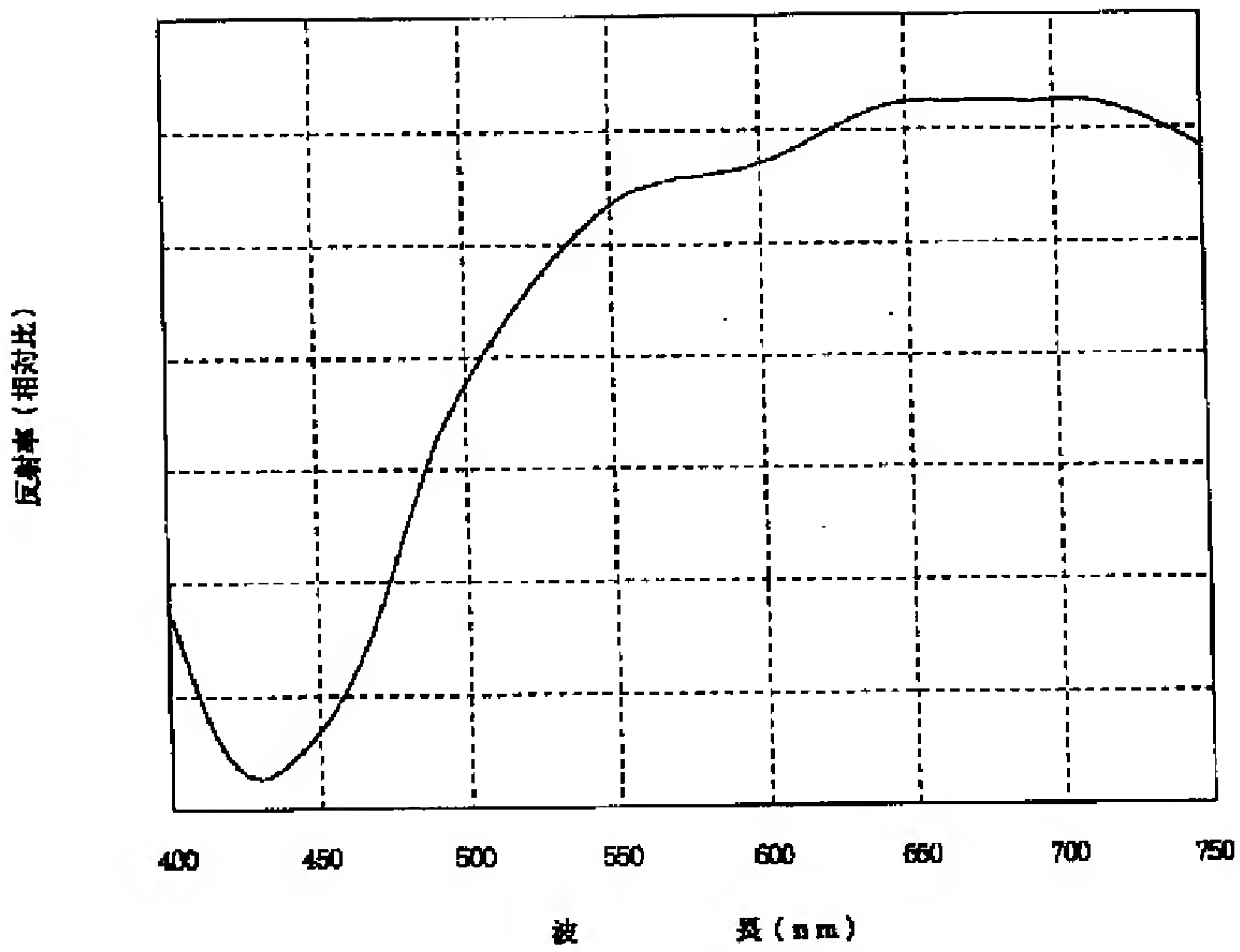
Drawing 1



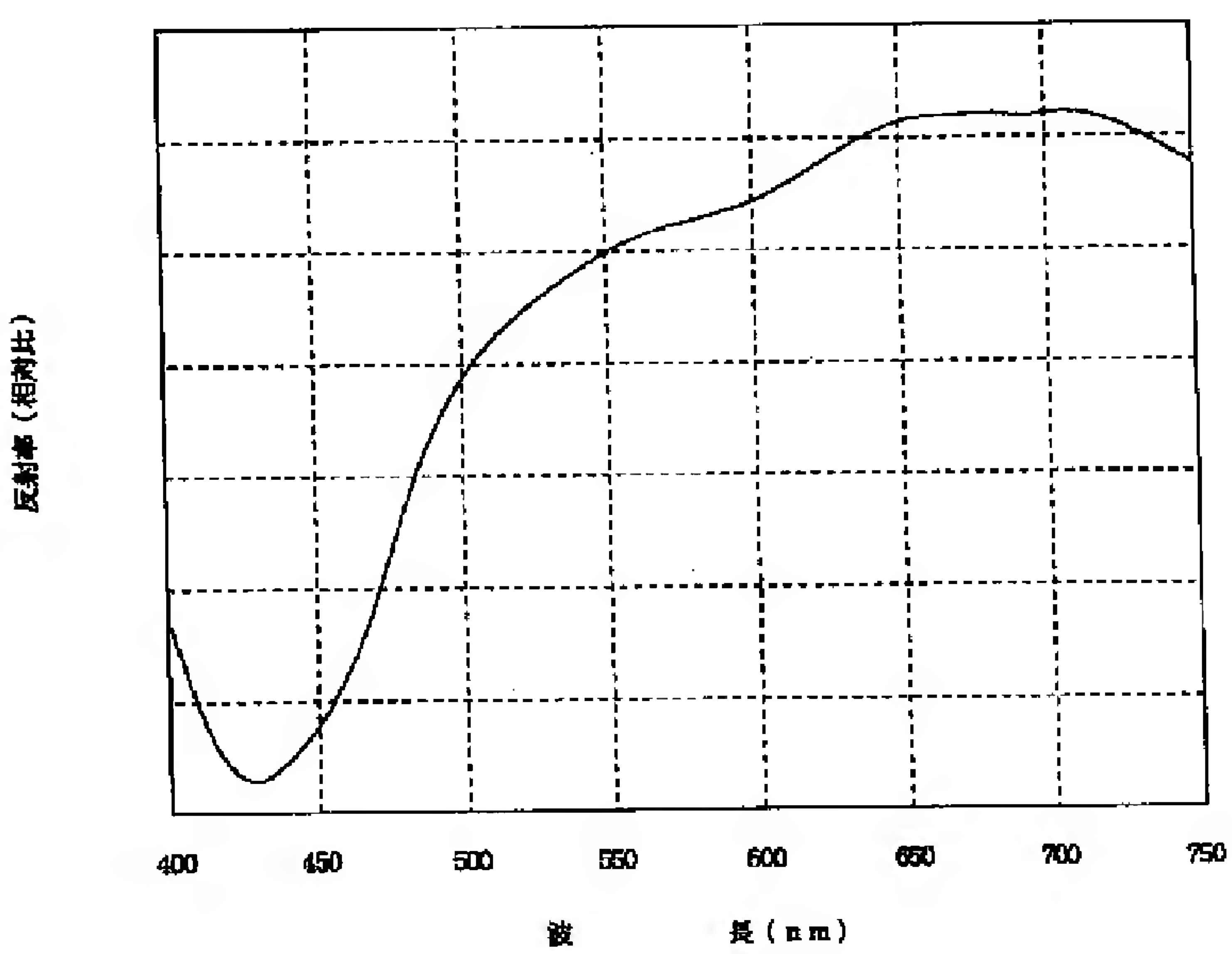
Drawing 2



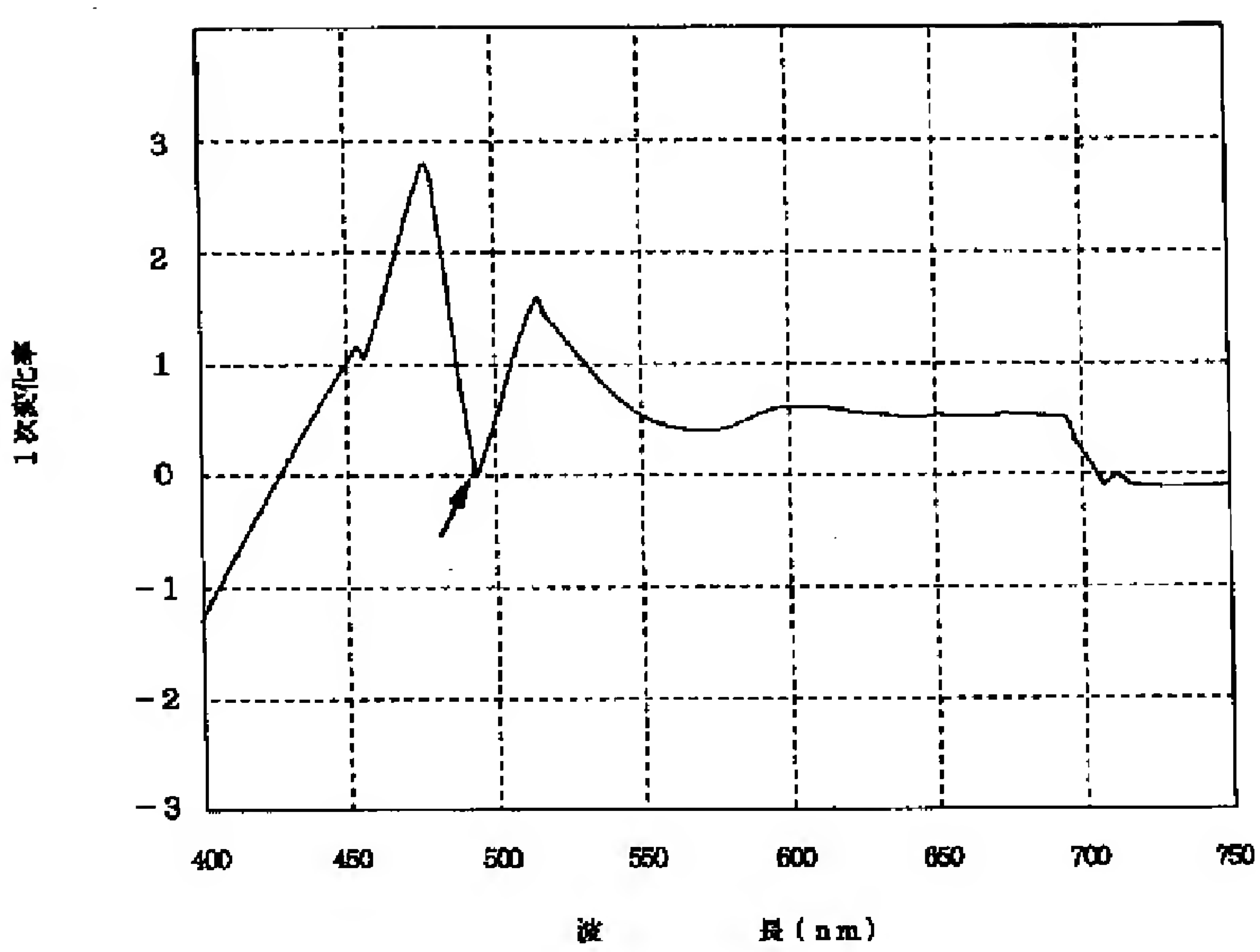
Drawing 3



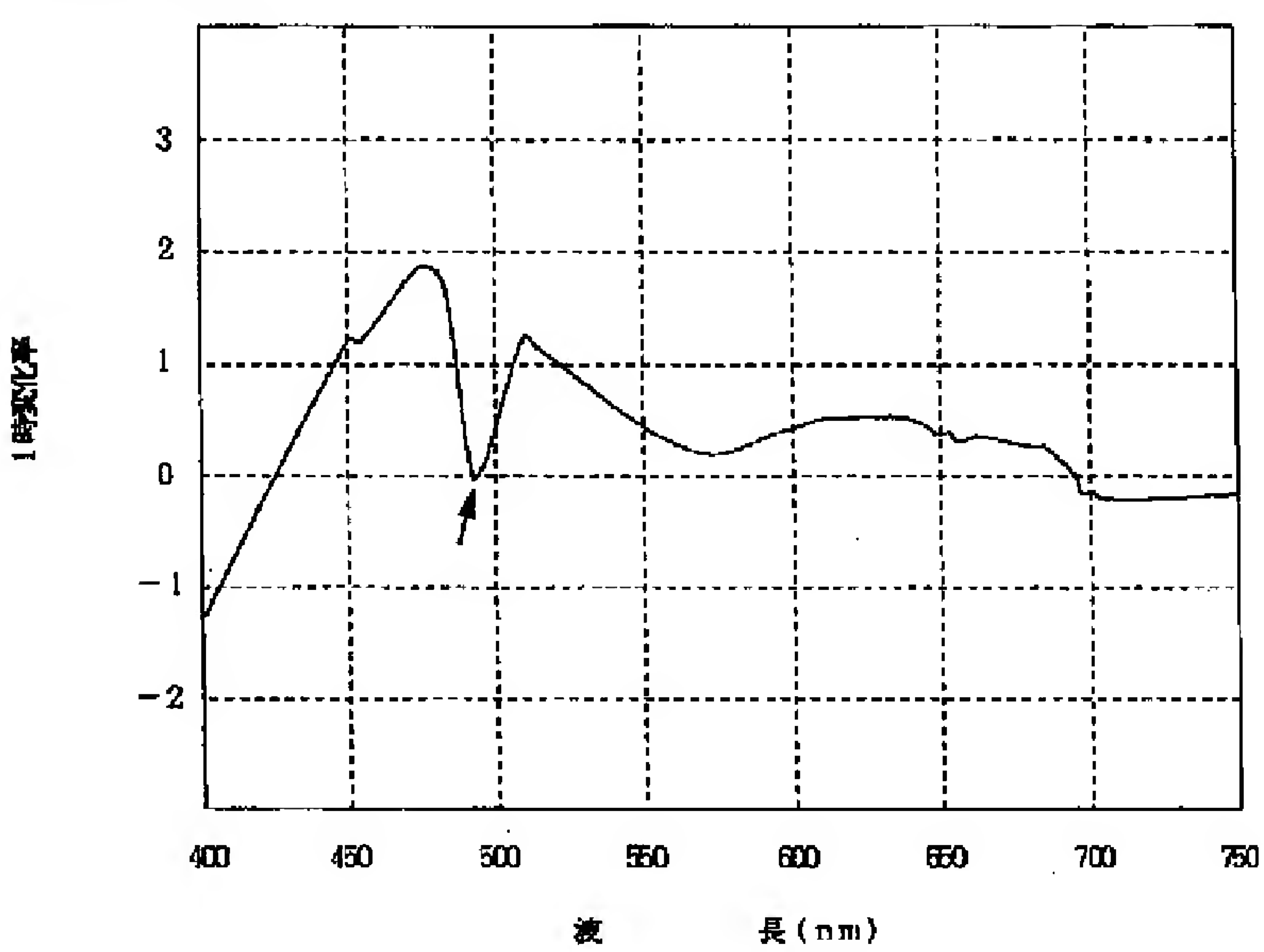
Drawing 4



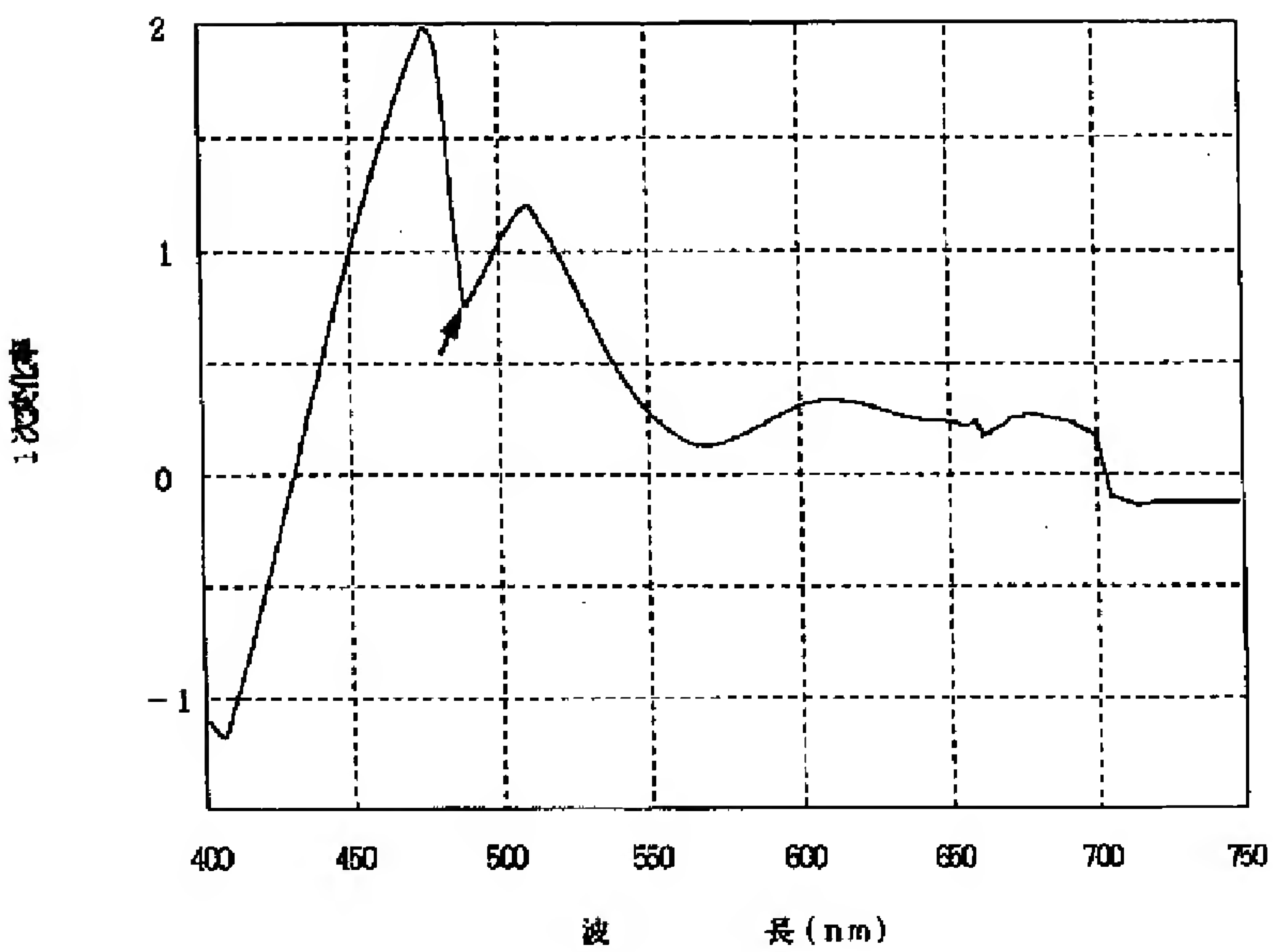
Drawing 5



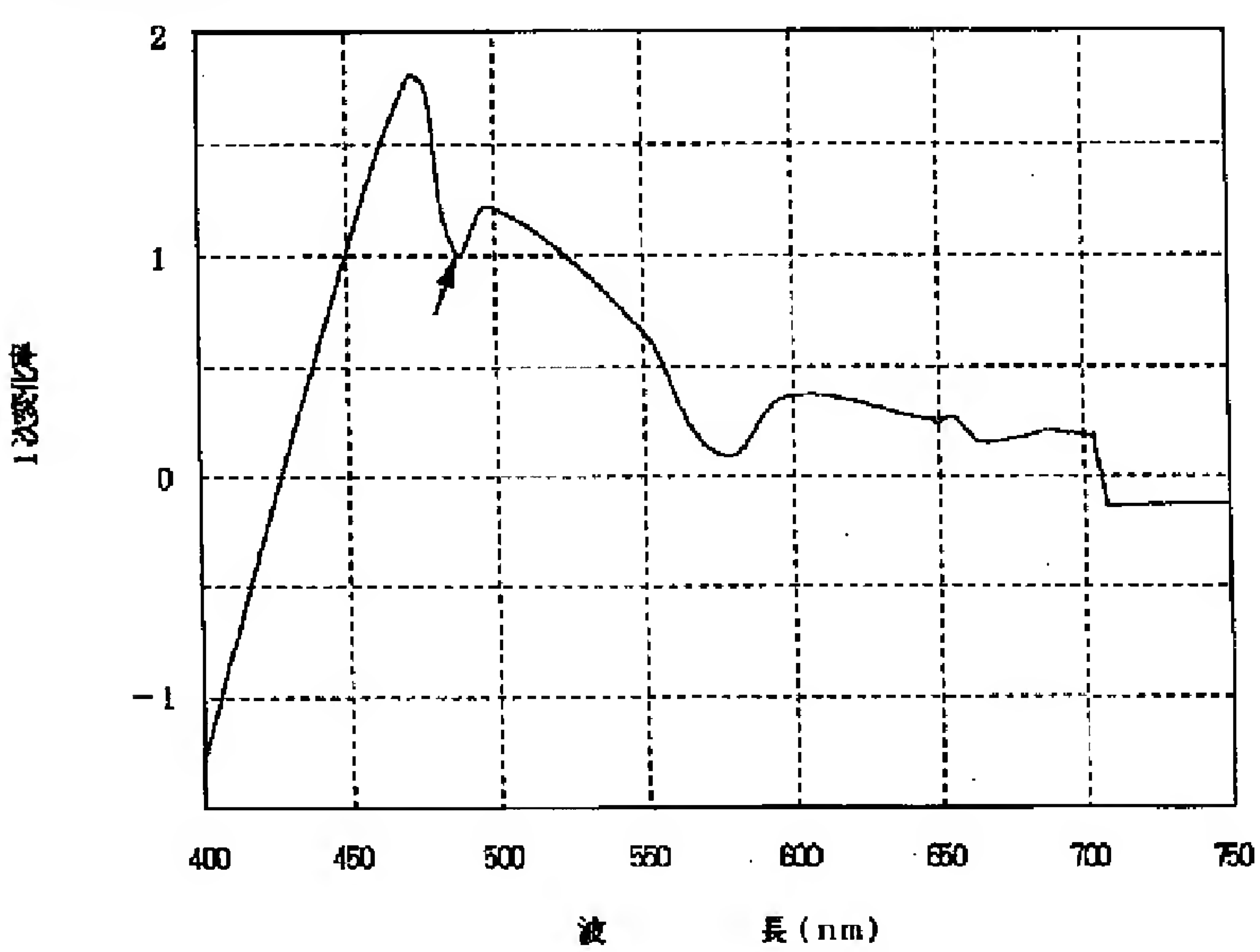
Drawing 6



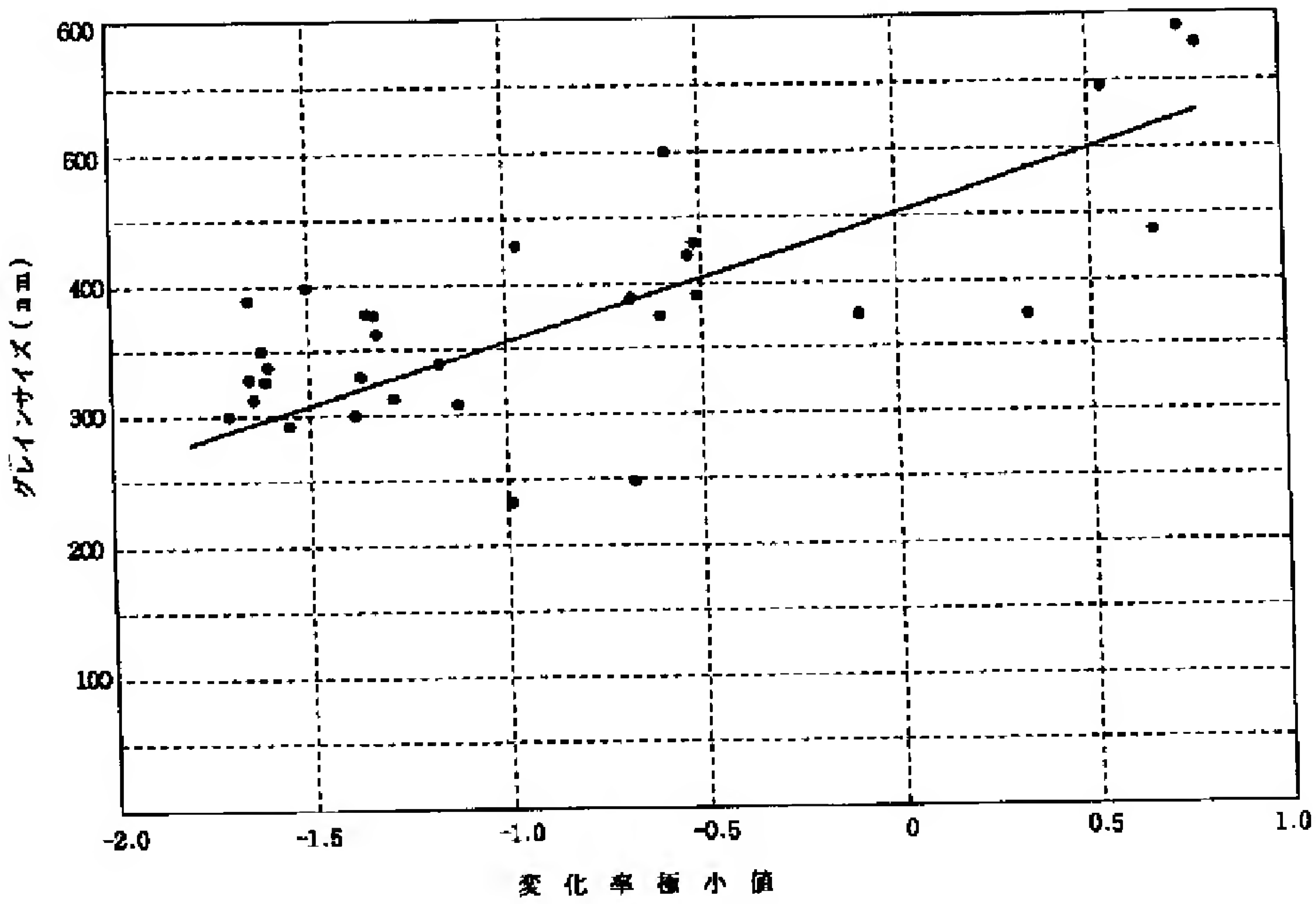
Drawing 7



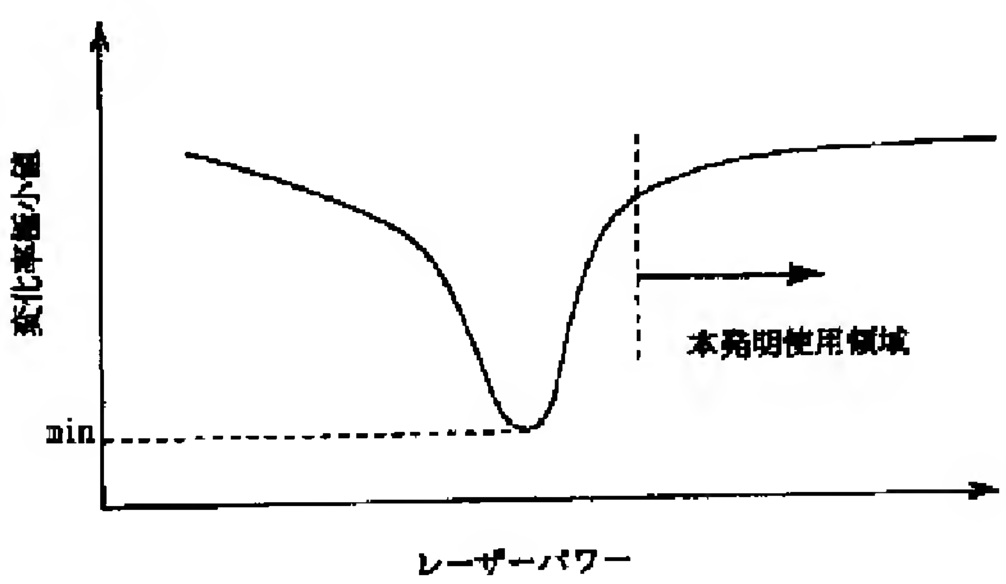
Drawing 8



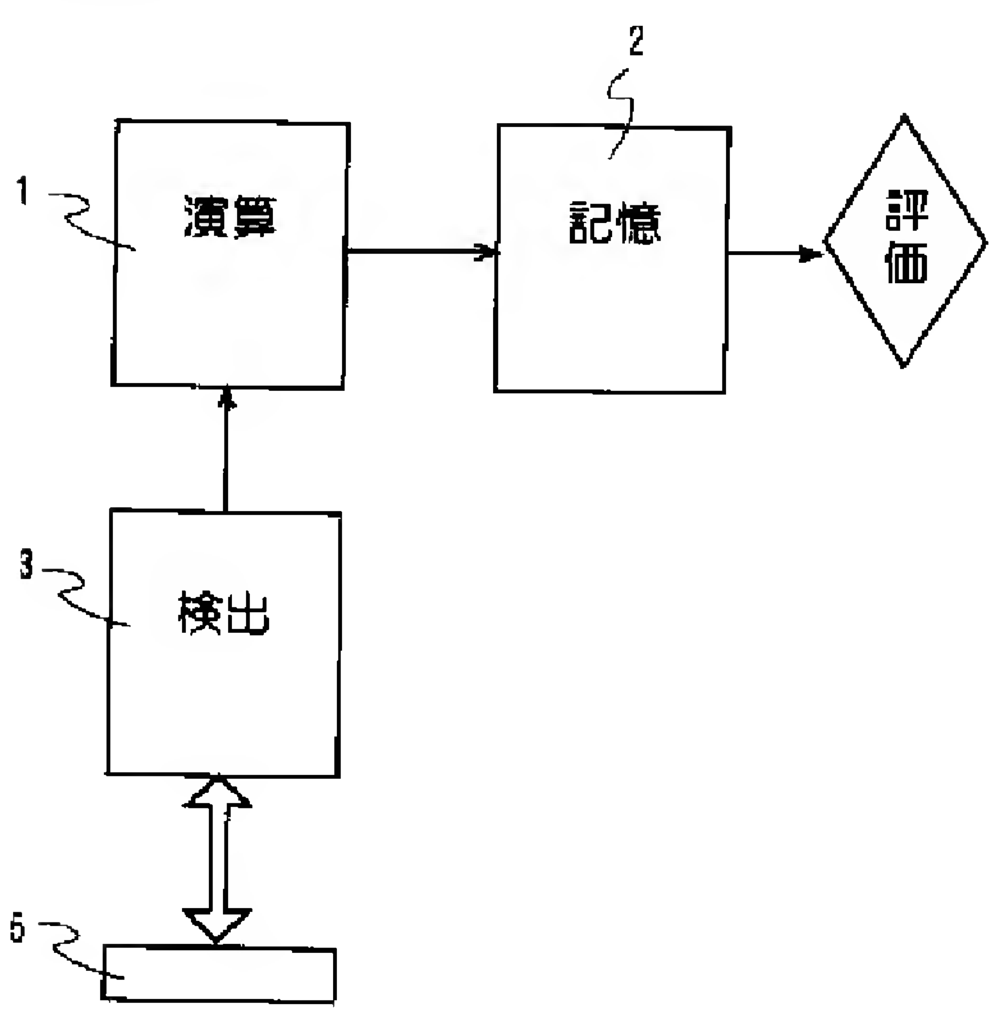
Drawing 9



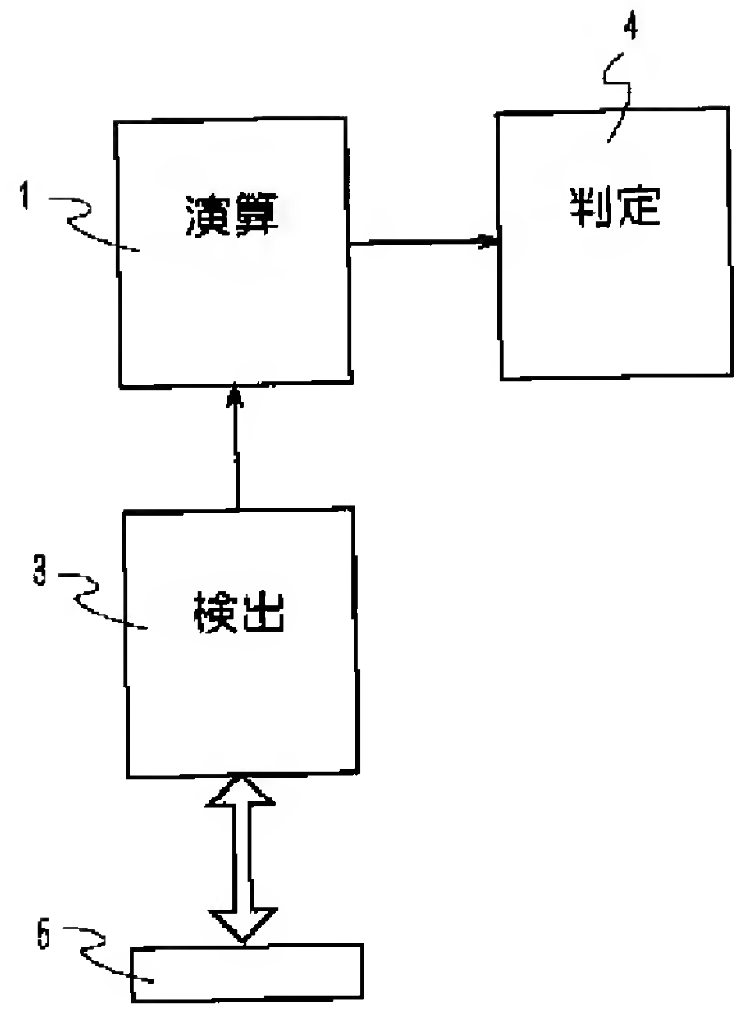
Drawing 10



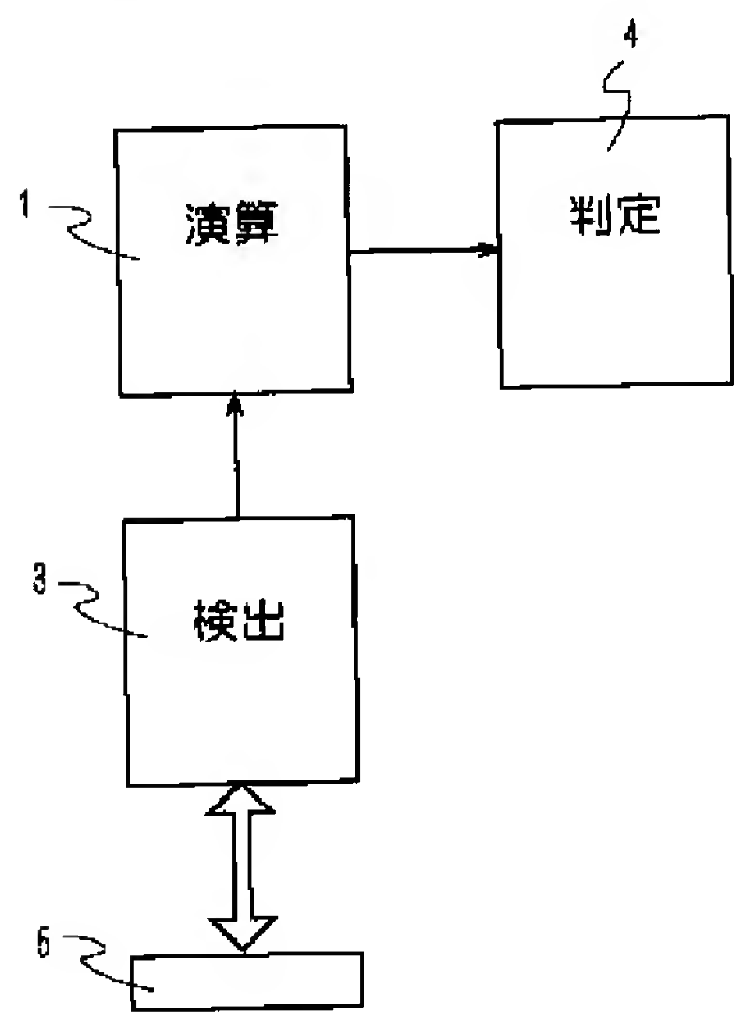
Drawing 11



Drawing 12



Drawing 13



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最終頁に続く

(54)【発明の名称】　半導体膜の評価方法、評価装置及び形成方法

(57)【特許請求の範囲】

【請求項１】　基板上の半導体膜の評価方法において、
複数の半導体膜の可視光領域における光の反射率曲線の1次変化率の極小値と、
その時の結晶粒径との対応をあらかじめ調べるとともに、
評価すべき半導体膜の前記可視光領域における光の反射率を測定し、
その反射率曲線の１次変化率の極小値を求め、
該極小値をあらかじめ調べた複数の極小値と結晶粒径との対応に照合することにより前記評価すべき半導体膜の結晶粒径を決定することを特徴とする半導体膜の評価方法。

【請求項２】　前記反射率は前記半導体膜に垂直に入射した光の反射率であり、

前記極小値は、前記波長に対する反射率曲線の傾きが局所的に変わる波長における１次変化率の値、または前記波長と反射率の１次変化率曲線が谷部を形成する波長における値であって、
前記波長は前記可視光領域内で５００ｎｍに最も近い波長であることを特徴とする請求項１に記載の半導体膜の評価方法。

【請求項３】前記半導体膜はレーザーアニールによって多結晶化ポリシリコンとなった半導体膜であることを特徴とする請求項１または請求項２に記載の半導体膜の評価方法。

【請求項４】　基板上の半導体膜を評価する半導体膜の評価装置において、
前記半導体膜に評価用可視光を照射する評価用光照射手段と、

前記評価用可視光の前記半導体膜からの反射光を検出する反射光検出手段と、
前記反射光検出手段からの情報を演算して前記半導体膜の可視光領域における光の反射率曲線の1次変化率の極小値を算出する演算手段と、
あらかじめ複数の同種の半導体膜に関して前記極小値と結晶粒径値とを対応させて保持した記憶手段と、
前記演算手段で算出された極小値を基に前記記憶手段から対応する結晶粒径値を選択して前記半導体膜の結晶粒径値を決定する評価手段と、
を有することを特徴とする半導体膜の評価装置。
【請求項５】 前記演算手段は、前記反射光検出手段からの情報を基に前記半導体膜の可視光領域における光の反射率曲線の１次変化率の極小値を算出し、前記記憶手段は、あらかじめ複数の同種の半導体膜に関して前記可視光領域における光の反射率曲線の１次変化率の極小値とその時の結晶粒径値とを対応させて保持している、ことを特徴とする請求項４に記載の半導体膜の評価装置。
【請求項６】 前記反射率は前記半導体膜に垂直に入射した光の反射率であり、
前記極小値は、前記波長に対する反射率曲線の傾きが局所的に変わる点における１次変化率の値、または前記波長と反射率の１次変化率曲線が谷部を形成する点における値であって、
前記波長は前記可視光領域内で５００ｎｍに最も近い波長であることを特徴とする請求項４または請求項５に記載の半導体膜の評価装置。
【請求項７】 前記半導体膜は、レーザーアニールによって多結晶化ポリシリコンとなった半導体膜であることを特徴とする請求項４から請求項６のいずれかに記載の半導体膜の評価装置。
【請求項８】 基板上の半導体膜の形成方法において、複数の半導体膜の可視光領域における光の反射率曲線の1次変化率の極小値とその時の結晶粒径との対応をあらかじめ調べ、
これに基づいて所望の結晶粒径を得るための閾値となる極小値を設定するとともに、
半導体膜を形成後にその形成した半導体膜の前記可視光領域における光の反射率曲線の1次変化率の前記極小値を求め、
該極小値を前記閾値とを比較して、前記形成した半導体膜の良否を判定することを特徴とする半導体膜の形成方法。
【請求項９】 基板上の半導体膜の形成方法において、複数の半導体膜の可視光領域における光の反射率曲線の1次変化率の極小値とその時の結晶粒径との対応をあらかじめ調べ、これに基づいて所望の結晶粒径を得るための閾値となる極小値をあらかじめ設定する工程と、
非晶質半導体膜を形成する工程と、
形成した非晶質半導体膜にレーザーアニールを施して結晶化する工程と、
この結晶化した半導体膜の前記可視光領域における光の反射率曲線の1次変化率の前記極小値を求め、該極小値を前記閾値と比較して、前記形成した半導体膜の良否を判定する工程と、
を有することを特徴とする半導体膜の形成方法。
【請求項１０】 前記反射率は前記半導体膜に垂直に入射した光の反射率であり、
前記極小値は、前記波長に対する反射率曲線の傾きが局所的に変わる波長における１次変化率の値、または前記波長と反射率の１次変化率曲線が谷部を形成する波長における値であって、
前記波長は可視光領域内で５００ｎｍに最も近い波長であることを特徴とする請求項８または請求項９に記載の半導体膜の形成方法。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、基板上に作成された半導体膜の評価方法、評価装置、形成方法に関し、特に、光学的観察により半導体膜の結晶粒径を割り出すことで、インライン化を可能とした半導体膜の評価方法、評価装置、形成方法に関する。
【０００２】
【従来の技術】基板上に半導体膜を作成する技術を用いることにより、集積回路の集積度を高めて大容量化を図る、あるいは、液晶を間に挟持した一対の基板の一方に、マトリクス表示部のスイッチング素子となる薄膜電界効果型トランジスタ（ＴＦＴ：Thin Film Transistor）を作り込み、高精細の動画表示を可能とするアクティブマトリクス型の液晶表示装置（ＬＣＤ：Liquid Crystal Display）の量産を行う等の開発が行われている。
【０００３】特に、シリコン基板に作製されたMＯＳＦＥＴに近い特性を示し得るようなＴＦＴを絶縁基板上に形成することができれば、ＬＣＤのマトリクス表示部のスイッチング素子のみならず、周辺にCＭＯＳを形成してマトリクス表示部に所望の駆動信号電圧を供給するための周辺駆動回路を一体的に作り込むことも可能となり、いわゆるドライバー内蔵型ＬＣＤの量産を行うことができるようになる。
【０００４】ドライバー内蔵型ＬＣＤは、液晶パネルにドライバー素子の外付けを行うことが不要となるため、工程の削減、狭額縁化が可能となる。特に、狭額縁化は、近年の携帯情報端末あるいはハンディビデオカメラのモニター等の用途においては、製品自体の小型化が図られる。このようなドライバー内蔵型ＬＣＤの実用化における重要な課題の一つとして、ガラス等の透明絶縁基板上に、基板の耐熱限界範囲内の温度で良質な半導体膜を作成することがある。従来、３００℃から４００℃程度の比較的低温で、非晶質状の半導体層特にアモルファ

スシリコン（ａ－Ｓｉ）を作成することで、ガラス基板上にＴＦＴを形成することが行われていた。しかし、このようなａ－ＳｉＴＦＴは、オン抵抗が高く、マトリクス表示部のスイッチ素子には適用することはできても、それよりも高速の動作が要求されるドライバー部を構成することを可能とするまでには到らなかった。

【０００５】これに対して、数百Åから数千Åの粒径を有した多数の単結晶粒（グレイン）が互いに接触した形で存在する多結晶半導体をチャンネル層に用いることで、ドライバー部にも適用できるＴＦＴを形成することができる。特に多結晶シリコン即ちポリシリコン（ｐ－Ｓｉ）は、移動度が数十から数百ｃｍ2／Ｖ・ｓ程度が得られ、ａ－Ｓｉよりも２桁大きく、ＬＣＤのドライバーを構成するには十分の速度を有したＣＭＯＳが形成される。

【０００６】このようなドライバー内蔵型ｐ－ＳｉＴＦＴＬＣＤを作成するには、ガラス基板上に膜質の良好なｐ－Ｓｉを成膜することが最も大きな課題となっている。通常、ｐ－Ｓｉは、基板上に成膜されたａ－Ｓｉに熱処理を施すことで結晶化を促す固相成長法（ＳＰＣ）、あるいは減圧ＣＶＤ等により直接に成膜するなどの方法により形成される。これらの成膜方法は、いずれも７００℃から９００℃程度の高温での処理であり、このような高温工程を含んだｐ－ＳｉＴＦＴＬＣＤの製造プロセスは高温プロセスと呼ばれる。高温プロセスにおいては、基板として耐熱性の高い石英ガラスなどの、高価な基板が要され、コストが高かった。

【０００７】このため、出願人は、以前より、コストを下げるために、プロセスの温度を最高でも６００℃程度以下とし、基板として、安価な無アルカリガラス基板等の採用を可能とする方法を開発してきた。このような、全プロセスを基板の耐熱性の限界温度以下に抑えたｐ－ＳｉＴＦＴＬＣＤの製造プロセスは、低温プロセスと呼ばれる。

【０００８】低温プロセスは、ａ－Ｓｉにエキシマレーザーを施すことで、結晶化を促してｐ－Ｓｉを作成するエキシマレーザーアニール（ＥＬＡ）により可能となった。エキシマレーザーは、励起状態にされたエキシマが基底状態に戻る際に発生する紫外光であるが、ＥＬＡでは、所定の光学系によりレーザービームの形状を加工して非処理膜に照射している。これにより、ａ－Ｓｉの表面に特に熱エネルギーが与えられ、基板の耐熱限界温度以下の温度で、結晶化が行われ、ｐ－Ｓｉが形成される。

【０００９】

【発明が解決しようとする課題】ＥＬＡでは、そのレーザーパワーの最適設定と、照射レーザーエネルギーのばらつきの問題を解決することが、主要な課題となっている。図１３に、照射レーザーエネルギーとｐ－Ｓｉの結晶粒径（グレインサイズ）との関係を示すように、ある点までは、付与エネルギーが大きくなるにつれて、グレインサイズも大きくなるが、ある点を越えると、グレインサイズが急激に小さくなり、微結晶化、即ち、マイクロクリスタルとなる。従って、十分に大きなグレインサイズ（ＧＭ）以上を得るためには、レーザー光源のパワーを下限Ｅdと上限Ｅuの間に最適に設定しなければならず、図１３の関係に基づいて、常時、ＥＬＡを管理する必要がある。

【００１０】特に、レーザー媒質の劣化に伴って、装置のパワー設定と実際に比処理膜に照射される実効エネルギーとのギャップが大きくなると、図１３に従ってｐ－Ｓｉのグレインサイズが目標値よりも小さくなてしまう。また、ＥＬＡ装置において、レーザー発振源にて発せられたレーザー光は、所定のレーザーアニールに適した非照射形状に整形するために長距離の光学系を通過するが、この際、光学系が湿気、異物等によって僅でも汚染されると、やはり実効エネルギーの低下を招く。

【００１１】更に、実効照射エネルギーのばらつきもまた問題となる。即ち、レーザービームの照射領域内で照射強度のばらつきが生じていると、照射エネルギーが図１３の最適範囲から外れた部分に対応した領域は、グレインサイズが十分に大きくならないといったことが問題となる。従来のｐ－Ｓｉのグレインサイズの評価方法として、セコエッチがあるが、この方法では、膜の評価を行った基板は、製品としては使用できず、他の基板の評価を類推することしかできない。

【００１２】本発明は、照射レーザーエネルギーのばらつくことからくる問題を解決することを目的とし、インラインモニターにより直接に当該のｐ－Ｓｉ膜の評価を行う方法、更には形成方法、形成装置を提供するものである。

【００１３】

【課題を解決するための手段】本発明は、この目的を達成するためになされ、半導体膜の可視光領域における光の反射率に基づいて半導体膜の結晶粒径を割り出す構成である。更に、基板上の半導体膜の評価法法において、複数の半導体膜の可視光領域における光の反射率曲線の１次変化率の極小値とその時の結晶粒径との対応をあらかじめ調べるとともに、評価すべき半導体膜の前記可視光領域における光の反射率を測定し、その反射率曲線の前記極小値を求め、該極小値を前記あらかじめ調べた複数の極小値と結晶粒径との対応に照合することにより前記評価すべき半導体膜の結晶粒径を決定する構成である。これにより、半導体膜を破壊することなく、結晶粒径の評価を行うことができる。

【００１４】また、本発明は、基板上の半導体膜を評価する半導体膜の評価装置において、前記半導体膜に評価用可視光を照射する評価光照射手段と、前記評価用可視光の前記半導体膜からの反射光を検出する反射光検出手段と、前記反射光検出手段からの情報を演算して前記半

導体膜の可視光領域における光の反射率曲線の1次変化率の極小値を算出する演算手段と、あらかじめ複数の同種の半導体膜に関して前記極小値と結晶粒径値とを対応させて保持した記憶手段と、前記演算手段で算出された極小値を基に前記記憶手段から対応する結晶粒径値を選択して前記半導体膜の結晶粒径値を決定する評価手段と、を有する構成である。

【００１５】特に、前記演算手段は、前記反射光検出手段からの情報を基に前記半導体膜の可視光領域における光の反射率曲線の１次変化率の極小値を算出し、前記記憶手段は、あらかじめ複数の同種の半導体膜に関して前記可視光領域における光の反射率曲線の１次変化率の極小値とその時の結晶粒径値とを対応させて保持している構成である。これにより、半導体膜を破壊することなく、結晶粒径の評価を行うことができるので、製造過程の中で結晶粒径を調べることができる。

【００１６】また、基板上の半導体膜の形成方法において、複数の半導体膜の可視光領域における光の反射率曲線の1次変化率の極小値とその時の結晶粒径との対応をあらかじめ調べ、これに基づいて所望の結晶粒径を得るための閾値となる極小値を設定するとともに、半導体膜を形成した後にその半導体膜の前記可視光領域における光の反射率曲線の1次変化率の前記極小値を求め、該極小値を前記閾値とを比較して、前記形成した半導体膜の良否を判定する構成である。

【００１７】更に、基板上の半導体膜の形成方法において、複数の半導体膜の可視光領域における光の反射率曲線の1次変化率の極小値とその時の結晶粒径との対応をあらかじめ調べ、これに基づいて所望の結晶粒径を得るための閾値となる極小値をあらかじめ設定する工程と、非晶質半導体膜を形成する工程と、形成した非晶質半導体膜にレーザーアニールを施して結晶化する工程と、この結晶化した半導体膜の前記可視光領域における光の反射率曲線の1次変化率の前記極小値を求め、該極小値を前記閾値と比較して、前記形成した半導体膜の良否を判定する工程とを有する構成である。

【００１８】これにより、半導体膜を破壊することなく、結晶粒径の評価を行うことができるので、製造過程の途中で、不良品を除くことができ、コストが削減される。

【００１９】図１から図４は、ａ－Ｓｉ膜にＥＬＡを施すことにより形成されたｐ－Ｓｉ膜の反射率の波長依存性（相対比）を測定した関係曲線図である。光照射及び採光装置としては大塚電子製のマルチチャンネル分光測定器を用いた。また、光照射及び反射光は対象膜に対し垂直方向にて行った。なお、その照射には４００ｎｍ～７５０ｎｍの可視光領域の光を用いた。図１はＥＬＡレーザーパワーが５２０ｍＪの場合、図２は同様に５３０ｍＪ、図３は５４０ｍＪ、図４は５５０ｍＪである。これらの図を見比べることにより以下のことが分かる。即ち、関係曲線が、波長５００ｎｍ付近で特徴的な形状を呈しており、その特異性そのものが更にレーザーパワーにも依存している。特に、図１及び図２においては、谷部となっている。このような、レーザーパワーに依存する反射率曲線の形状の変化は、ｐ－Ｓｉ膜のグレインサイズの変化に起因するものである考えられる。

【００２０】そこで、出願人は、反射率曲線を微分して１次変化率を求めた。図５から図８は、各々図１から図４の反射率曲線の１次変化率の波長依存性曲線である。図１から図４と同様、５００ｎｍ付近において、反射率曲線の特異部を強調した形で、変化率曲線の振れが大きくなっている。即ち、図１から図４における反射率曲線の特異部分、より詳しくは、波長が大きくなるに従って反射率も高くなる５００ｎｍ付近の領域において、局所的に反射率曲線の傾きが変わっている、更には、低下して谷となっているところがあり、そのような波長－反射率の関係が、図５から図８においては、変化率曲線の谷部での矢印にて示すような極小の深さとして明確に表されている。本発明では、この極小値をもって、各々の条件の下でＥＬＡが行われた場合の固有の値である光学的値として代表させる。

【００２１】図9は、このようにして得られた光学的値と、その時の実際のｐ－Ｓｉ膜にセコエッチ等により実測して得られたグレインサイズとの関係を多数の試料に関して調べた図である。実線は、これらの関係の傾向線である。これより、光学的値が大きくなればなるほど、即ち、図１から図４の反射率曲線の特異部が緩和されればされる程、グレインサイズが大きくなっていることがわかる。即ち、これらの条件範囲においてはグレインサイズは光学的値に対してリニアに変化している。従って、反射率の変化率を調べることで、グレインサイズを割り出すことができる。

【００２２】このような、反射率あるいはその変化率の波長依存性が、特定波長領域において特異な性質を示すことについて、そのメカニズムは明白ではないが、結晶秩序度に依存して反射と乱反射の優劣が変化し、それが特に上述の波長域において顕著に現れるものと推測される。従って、このような光学的性質を調べることから逆算的に結晶粒径を割り出すことができる。

【００２３】ここで、更に、経験的につきとめられたことは、光学的値とレーザーエネルギー（グレインサイズ）との関係は図１０に示すような特徴を有しているということである。即ち、あるエネルギー領域において、光学的値が最小値となり、その両側では、対称的に光学的値が上昇する関係となっている。そして、実験的にこのような光学的値の最小値をとるエネルギー密度は、だいたい３００ｍＪ／ｃｍ2から３５０ｍＪ／ｃｍ2の間にあり、ＥＬＡにおけるレーザーパワーは、エネルギー密度が４００ｍＪ／ｃｍ2から５００ｍＪ／ｃｍ2程度の範囲での微調整が要請されることを考えると、光学的値と

レーザーパワー即ちグレインサイズとの関係はほぼ直線の形状を呈することがわかる。

【００２４】図１１は、本発明の実施の形態に係る評価装置の構成図である。（１）は演算部、（２）は記憶部、（３）は検出部、（５）は評価すべき半導体膜が形成された被処理基板である。検出部（３）は、ハロゲンランプ等の発光素子と採光素子とが同軸ファイバーを構成している。被処理基板（５）は、絶縁基板上に形成されたａ－ＳｉにＥＬＡが施されて結晶化されてｐ－Ｓｉが形成されている。検出部（３）は、この被処理基板（５）に検出用の光を照射するとともに、その反射光を検出して分光特性を調べる。この分光特性情報は演算部（１）に送られる。演算部（１）では、図１から図４に示す反射率の波長依存性を算出し、これから、図５から図８に示す反射率の１次変化率を求め、更に、その極小値を調べて光学的値を決定する。この光学的値は記憶部（２）に送られる。記憶部（２）には、図９に示す光学的値とその時のグレインサイズとが対応して保持されている。記憶部（２）は、例えば、光学的値に基づく情報をアドレスとしたグレインサイズの値が保持された不揮発メモリである。従って、演算部（１）より送られた光学的値に基づいてアドレスが生成されて、グレインサイズの値が読み出される。このようにして得られたグレインサイズは、その被処理基板（５）のグレインサイズとして決定される。このようなグレインサイズの測定は、被処理基板（５）上の複数ポイントで行うことにより、ＥＬＡエネルギーの照射領域内におけるばらつきを管理することができる。また、記憶部（２）に保持される情報は、ＥＬＡ装置の特性や、装置の使用時間に応じて、書き換えたり、メモリを交換する等により、長期的な条件変動にも対応することもできる。

【００２５】このような本発明におけるｐ－Ｓｉ膜の評価は、光反射率の測定、即ち、適当な光照射とその反射光の採光により行われる。従って、インラインモニタリングが可能となり、ｐ－Ｓｉ膜の形成工程直後に、本発明にかかるグレインサイズ測定工程を設置して、ＥＬＡの管理を行うことができる。図１２は、製造プロセスに導入される評価装置である。（１）、（３）、（５）は、各々図１１と同じ演算部、検出部、被処理基板である。（４）は判定部である。判定部（４）には、目標とするｐ－Ｓｉのグレインサイズの許容範囲の上限に対応する光学的値と下限に対応する光学的値とが設定されている。演算部（１）より送られた光学的値は、これら上限及び下限の光学的値と比較されて、当該の被処理基板（５）のグレインサイズが、許容範囲内にあるか否かが調べられ、その被処理基板（５）の良否が判定される。被処理基板（５）が不良と判定された時は、その被処理基板（５）は次工程への移送が禁止される。

【００２６】このように、ＥＬＡ工程の後に、本発明の評価工程を設置することで、ＥＬＡ直後のグレインサイズを測定し、湿気や異物、光学系の汚染、レーザー光源の消耗等、何らかの理由によりレーザー照射エネルギーが変化して、グレインサイズが十分に大きくならなかった場合、即、製造を中止して破棄する、あるいは、ｐ－Ｓｉ膜のエッチング工程に送り、ｐ－Ｓｉ膜を除去して、再び成膜工程からやり直す等の措置が講じられる。更に、ＥＬＡと本発明の評価工程を一体化することで、レーザー照射を行いながら、ｐ－Ｓｉ膜の評価を同時的に行い、ＥＬＡにフィードバックすることで、レーザーパワーを常時最適に調整しながらのＥＬＡが可能となる。

【００２７】

【発明の効果】本発明で、半導体膜の結晶粒径の評価工程が製造工程に挿入可能となったので、常時、半導体膜形成工程の管理を行うことができる。これにより、形成直後の半導体膜の膜質が許容範囲外になった場合、即、製造を中止することができ、不良品を早い段階で発見することができる。このため、余分なコストが削減され、歩留まりが向上される。また、製造工程と平行して膜評価を行い、これを半導体膜形成工程に反映されることで、常時、最適な条件に微調整されるので、特性の良好な半導体装置が製造される。

【図面の簡単な説明】

【図１】本発明におけるｐ－Ｓｉ膜の反射率の波長依存性を測定した関係図である。

【図２】本発明におけるｐ－Ｓｉ膜の反射率の波長依存性を測定した関係図である。

【図３】本発明におけるｐ－Ｓｉ膜の反射率の波長依存性を測定した関係図である。

【図４】本発明におけるｐ－Ｓｉ膜の反射率の波長依存性を測定した関係図である。

【図５】図１における反射率の波長依存性の曲線から１次変化率を求めた関係図である。

【図６】図２における反射率の波長依存性の曲線の１次変化率を求めた関係図である。

【図７】図３における反射率の波長依存性の曲線の１次変化率を求めた関係図である。

【図８】図４における反射率の波長依存性の曲線の１次変化率を求めた関係図である。

【図９】１次変化率の極小値とｐ－Ｓｉ膜のグレインサイズとの関係図である。

【図１０】レーザーエネルギーと１次変化率の極小値との関係図である。

【図１１】本発明の実施の形態にかかる半導体膜の評価装置の構成図である。

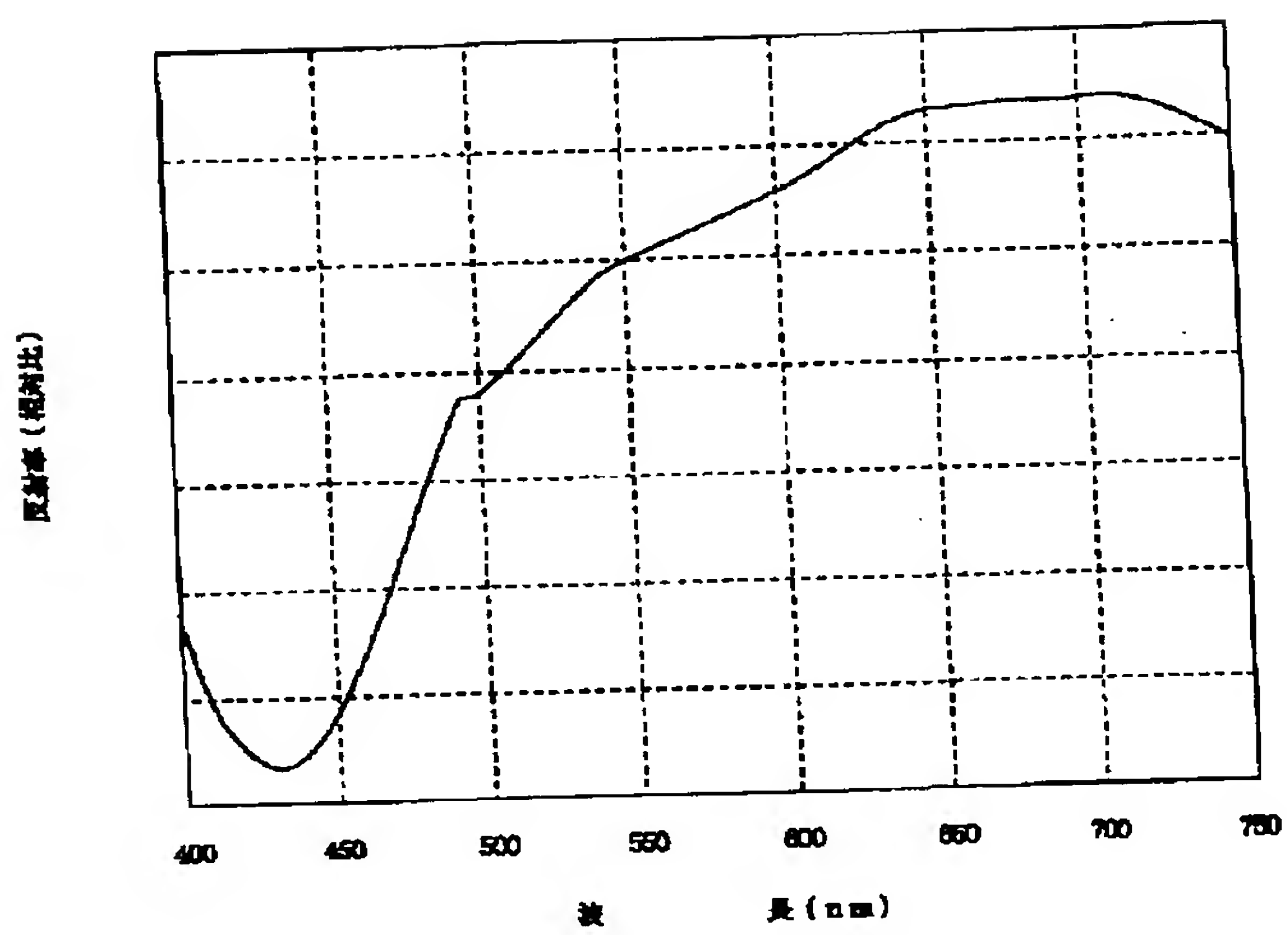
【図１２】本発明の実施の形態にかかる半導体膜の形成装置の構成図である。

【図１３】照射レーザーエネルギーとグレインサイズとの関係図である。

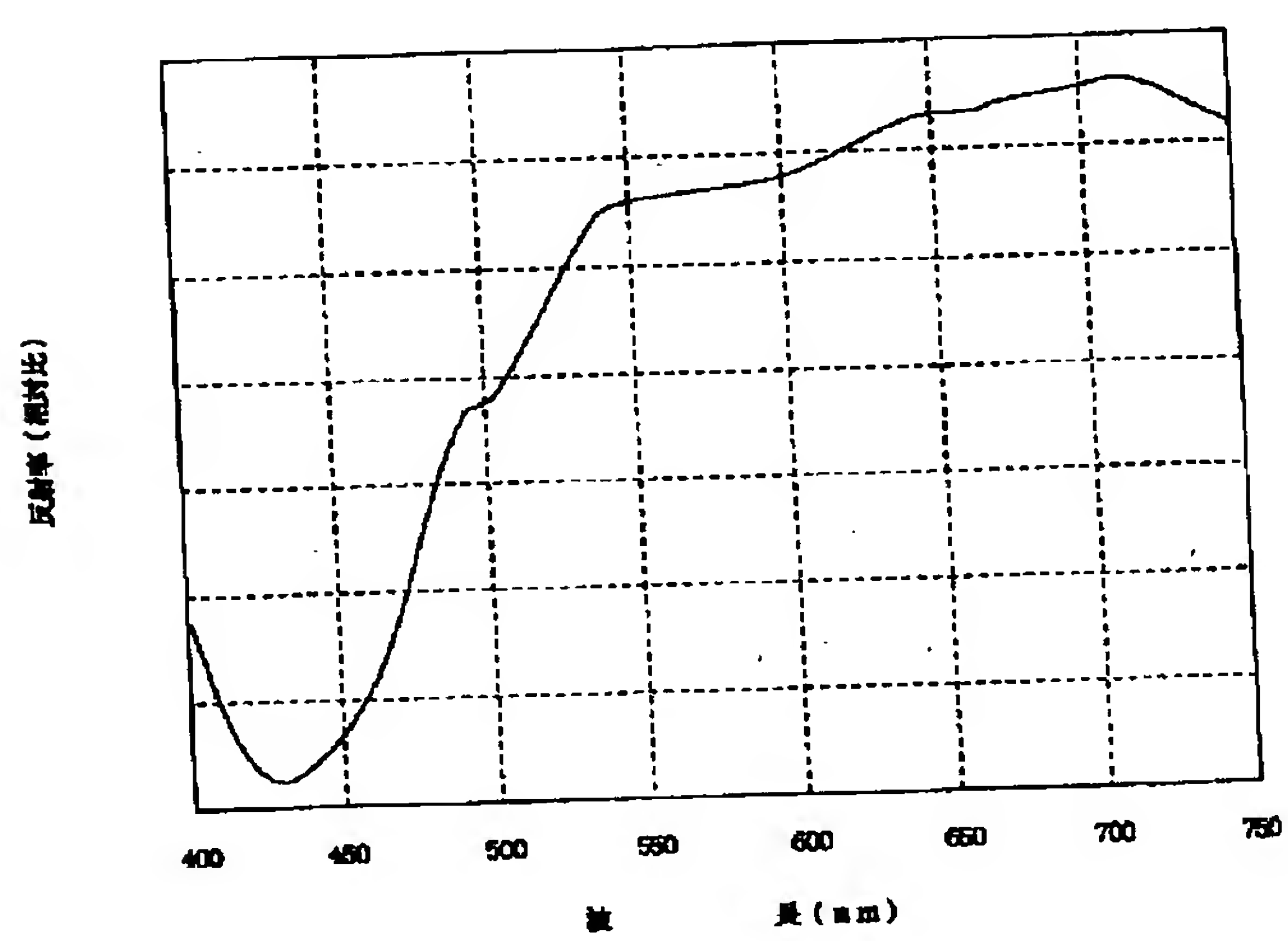
【符号の説明】

1　演算部
2　記憶部
3　検出部
＊4　判定部
5　被処理基板
＊

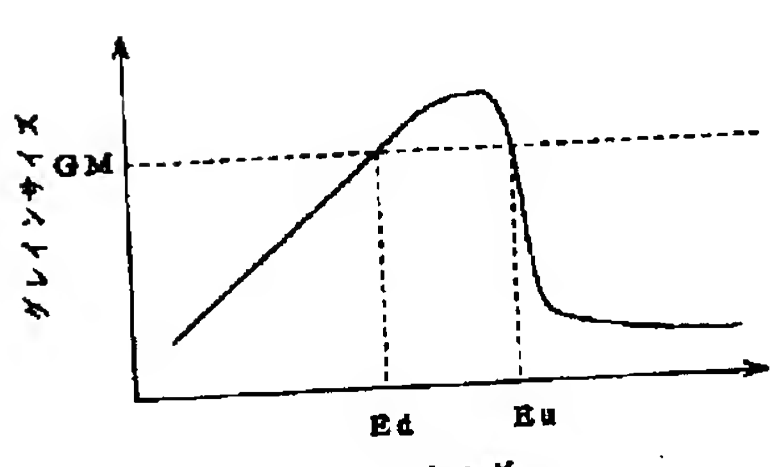
【図１】



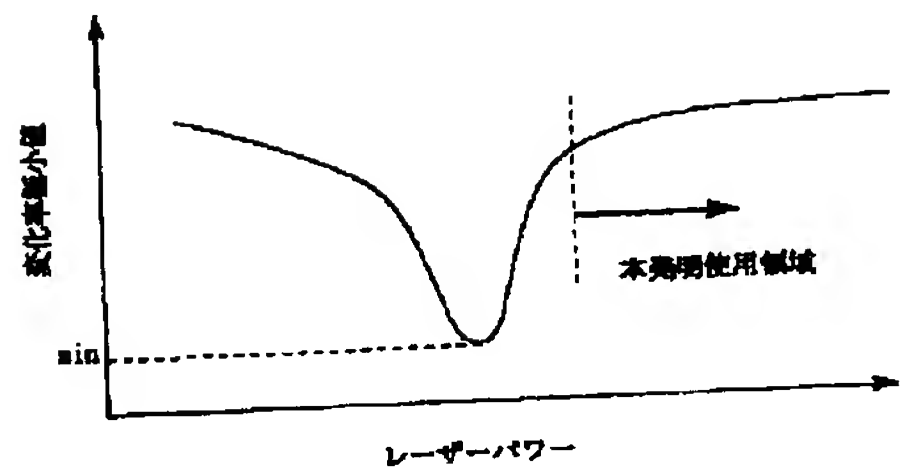
【図２】



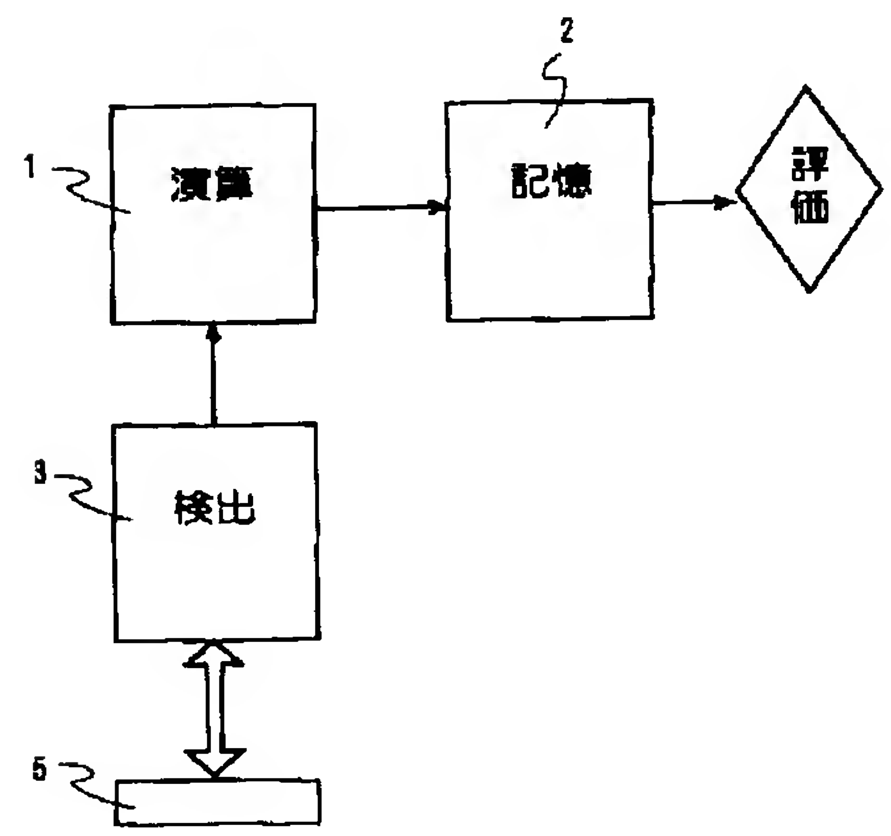
【図１３】



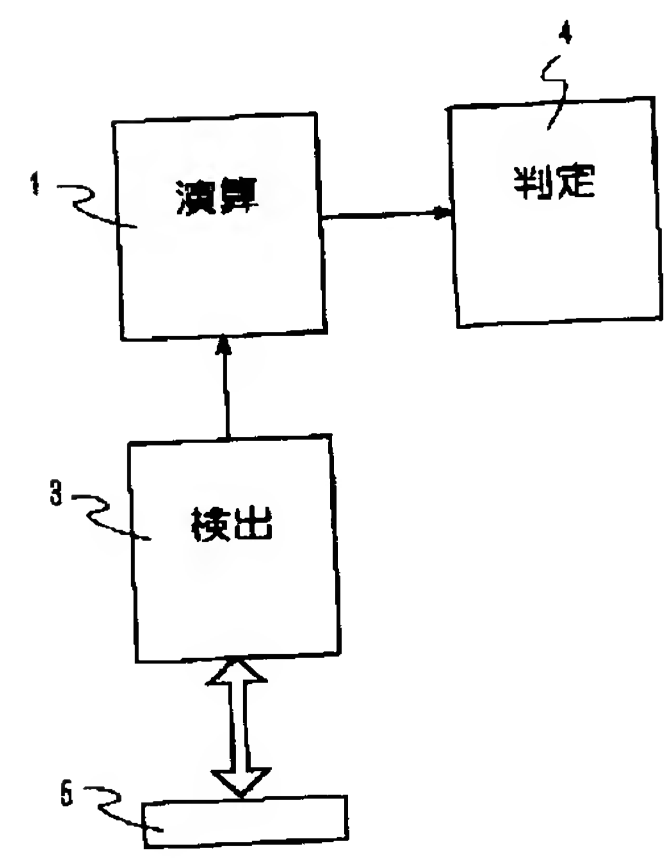
【図１０】



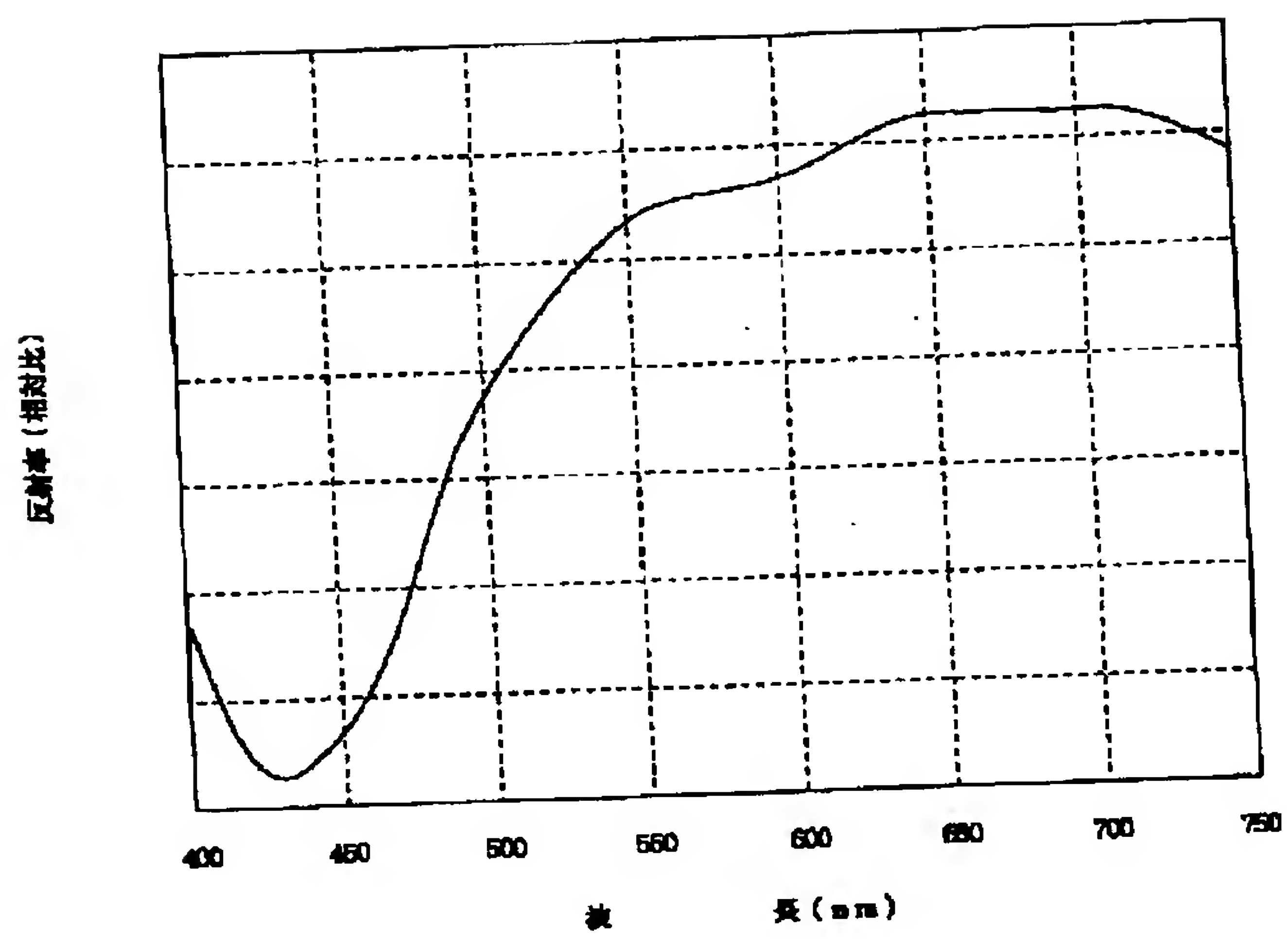
【図１１】



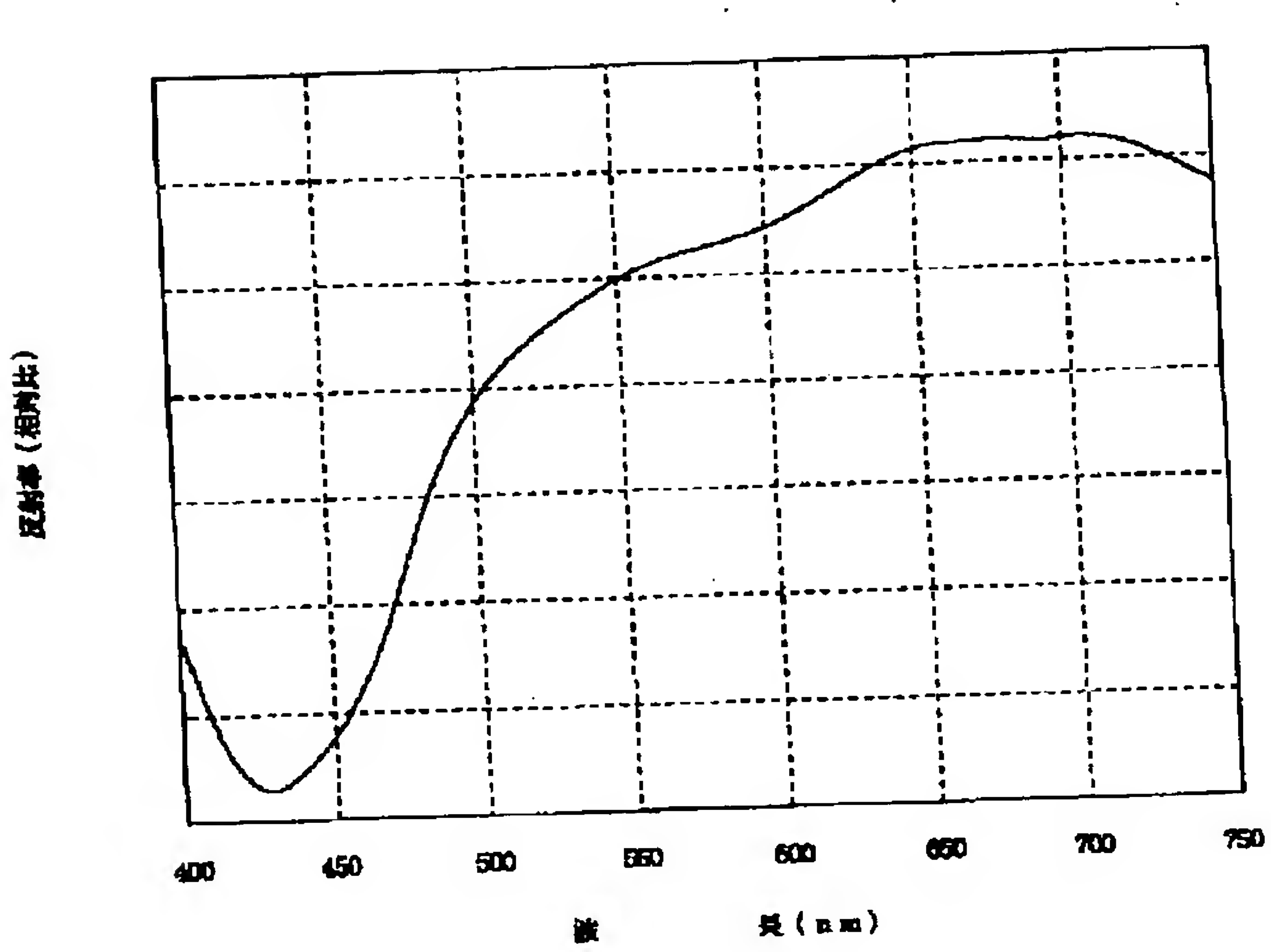
【図１２】



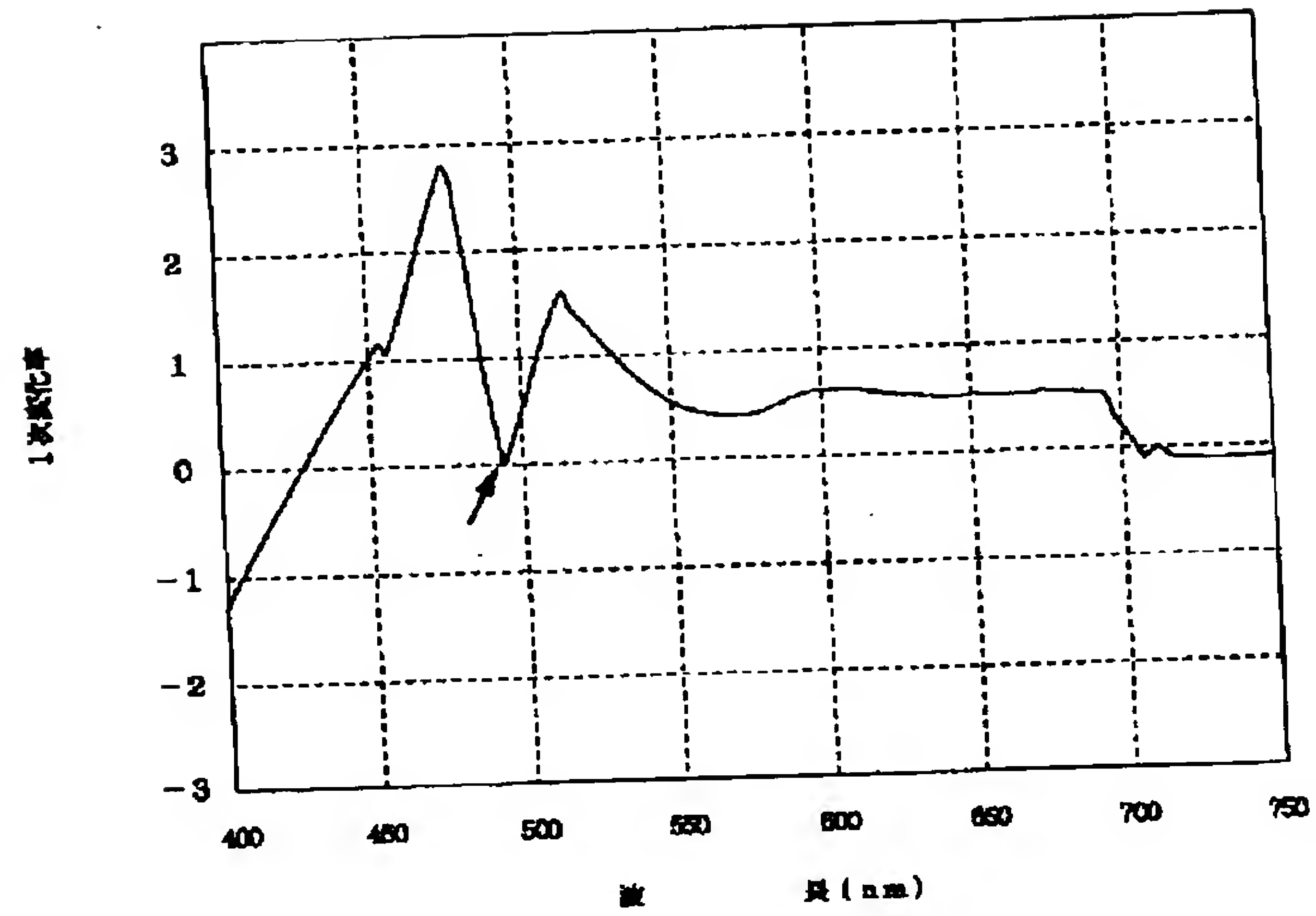
【図３】


反射率（相対比）
400
450
500
550
600
650
700
750
波長（nm）

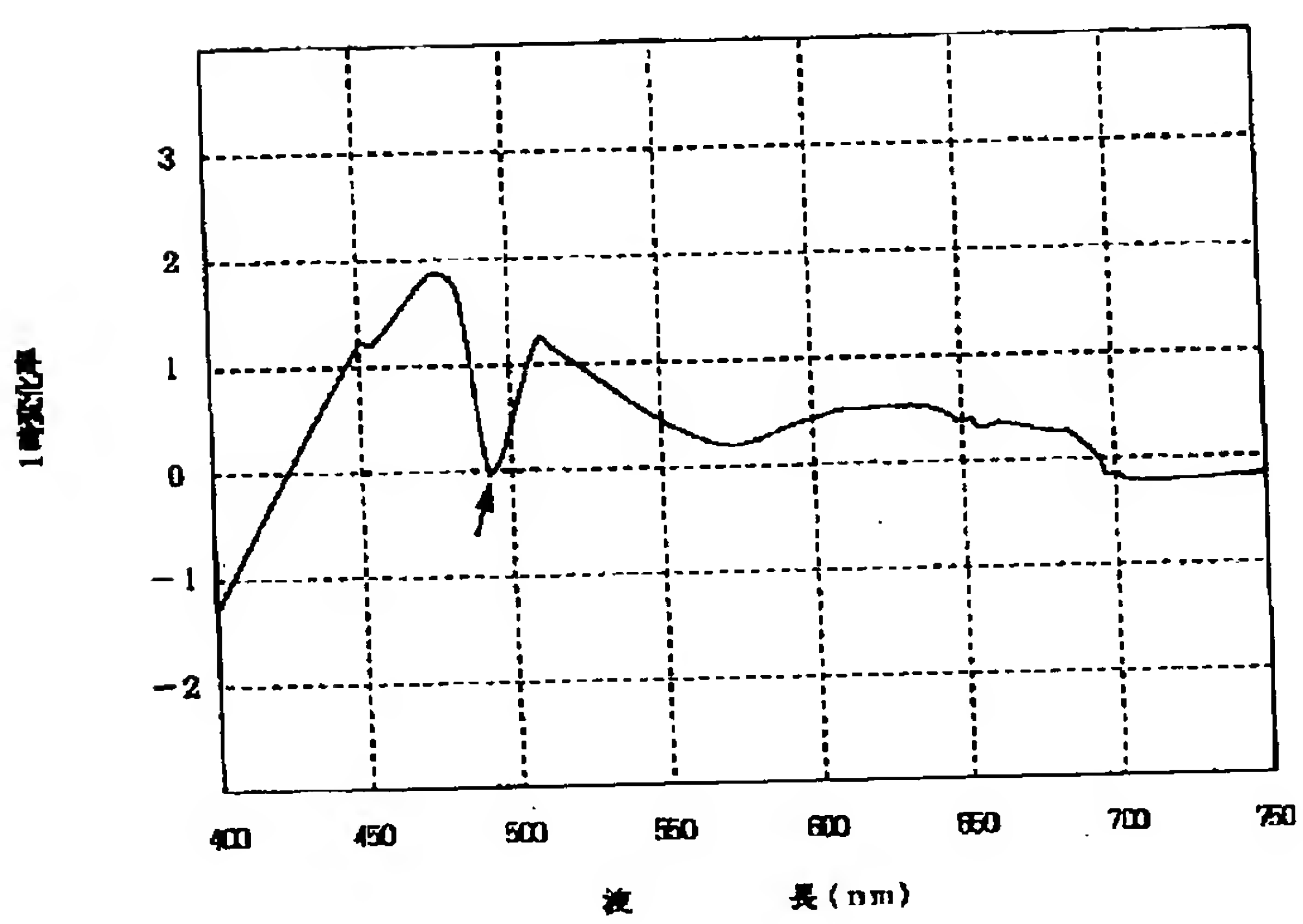
【図４】


反射率（相対比）
400
450
500
550
600
650
700
750
波長（nm）

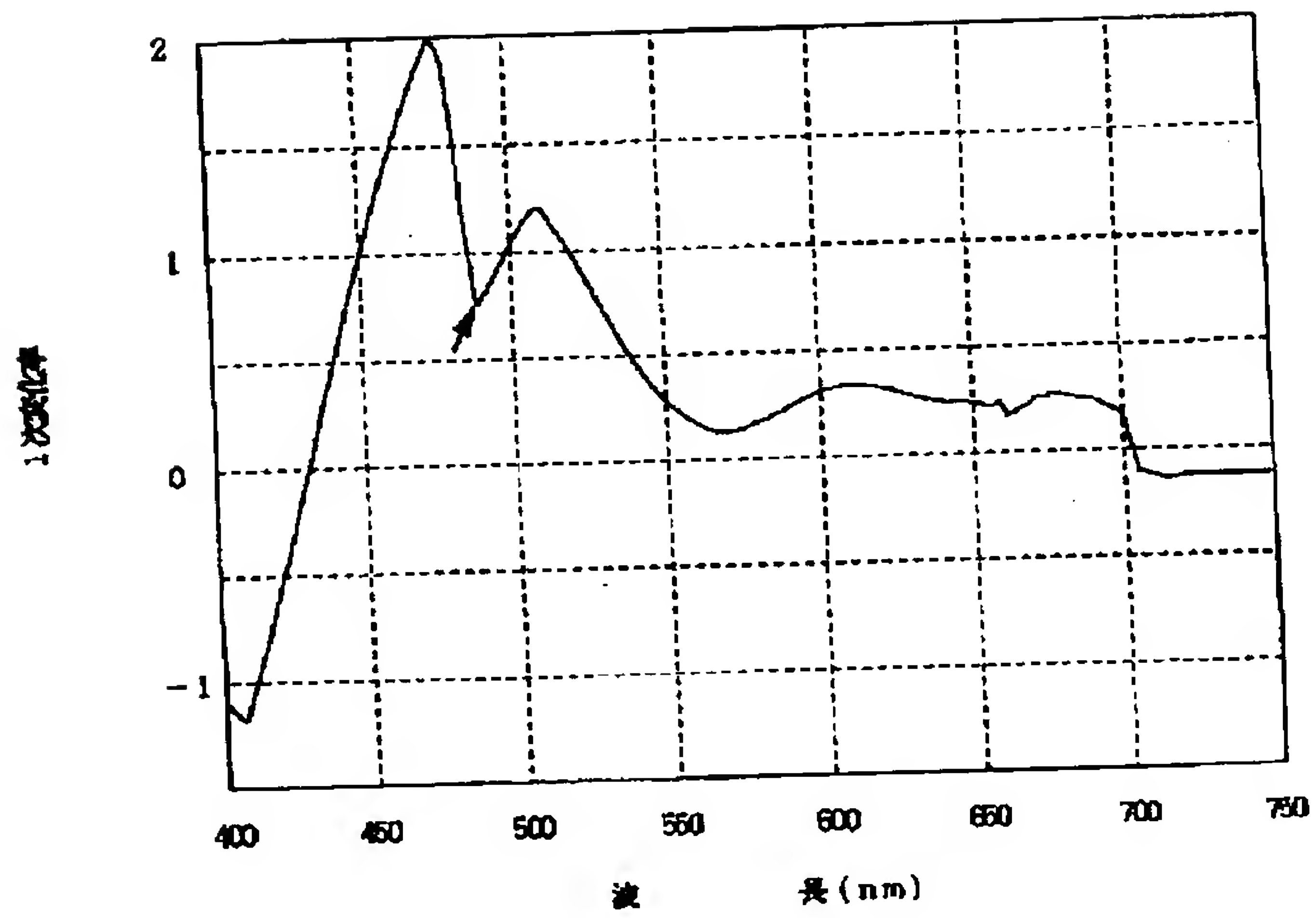
【図５】


3
2
1
0
−1
−2
−3
1次変化率
400
450
500
550
600
650
700
750
波　　長（nm）

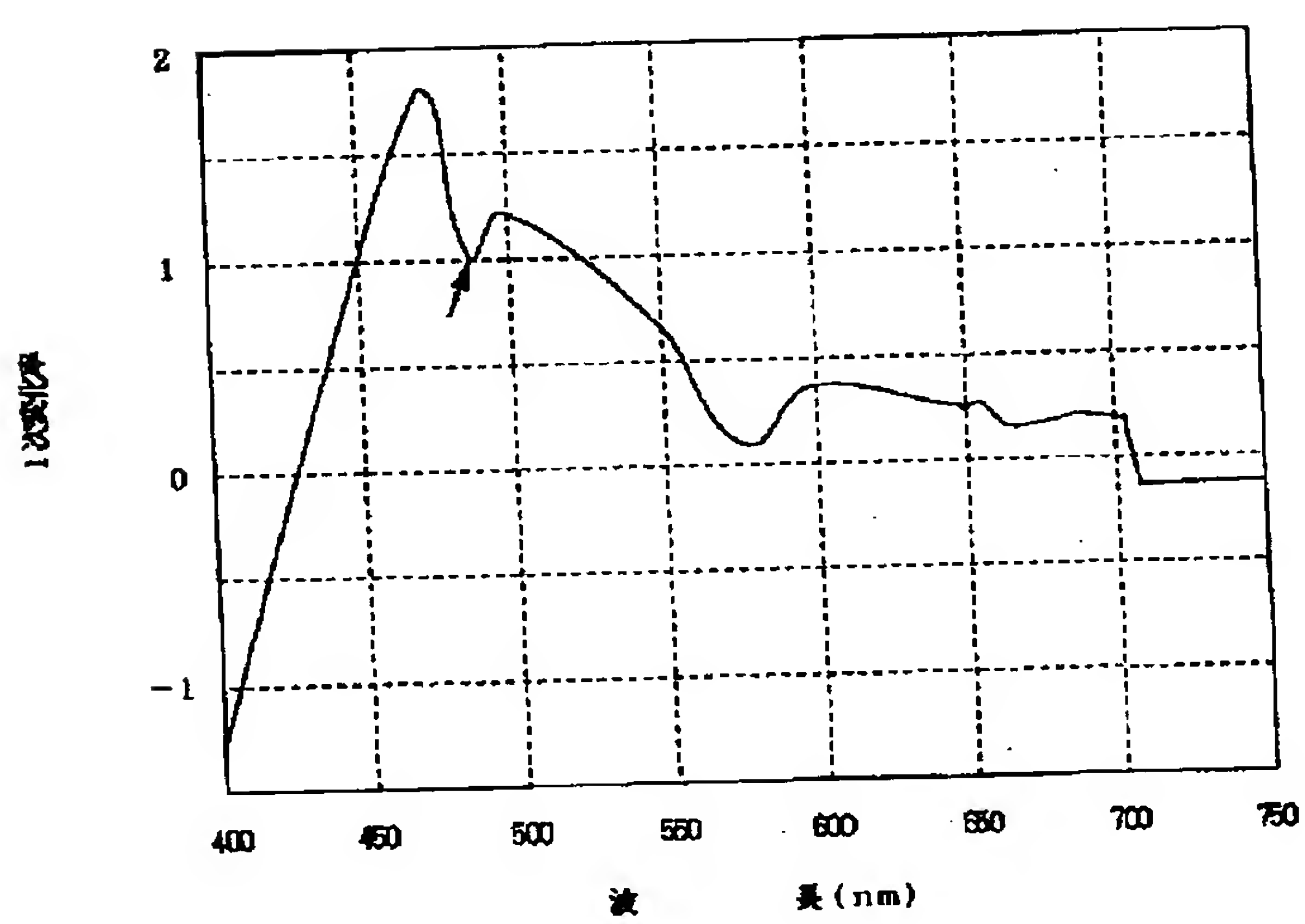
【図６】


3
2
1
0
−1
−2
1次変化率
400
450
500
550
600
650
700
750
波　　長（nm）

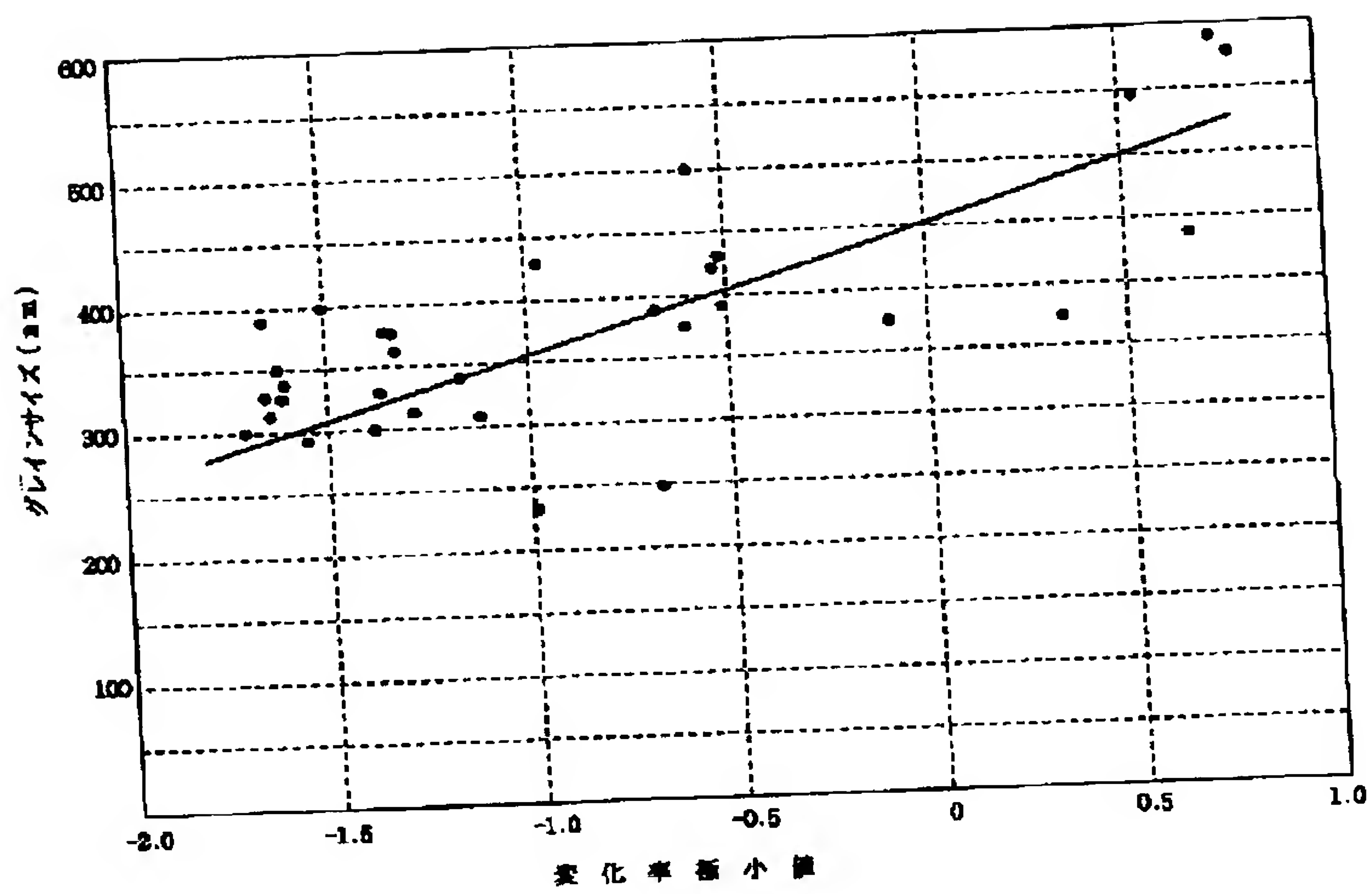
【図７】


2
1
0
−1
1次微分値
400
450
500
550
600
650
700
750
波長(nm)

【図８】


2
1
0
−1
1次微分値
400
450
500
550
600
650
700
750
波長(nm)

【図９】



フロントページの続き

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(56)参考文献　特開　昭63－163257（ＪＰ，Ａ）
特開　昭61－272636（ＪＰ，Ａ）
特開　平６－341952（ＪＰ，Ａ）

(58)調査した分野(Int.Cl.⁷，ＤＢ名)
G01N　21/00 － 21/01
G01N　21/17 － 21/61
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(30)Priority

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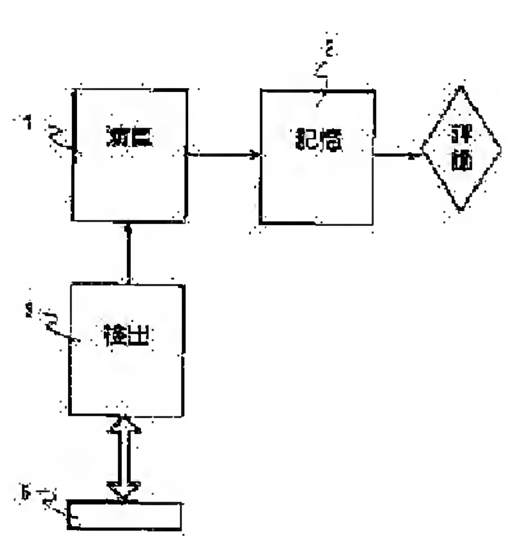
(54) METHOD AND UNIT FOR EVALUATING SEMICONDUCTOR FILM AND METHOD FOR FORMING SEMICONDUCTOR FILM



(57)Abstract:

PROBLEM TO BE SOLVED: To manage the process for forming a semiconductor film constantly during the production process by evaluating the crystal grain size of a semiconductor film based on the reflectance of light in a specified wavelength region thereof.
SOLUTION: The unit for evaluating a semiconductor film, e.g. a polysilicon (p-Si) film deposited on a glass substrate by excimer laser anneal ELA, being employed in a liquid crystal display comprises an operating section 1, a memory section 2 and a detecting section 3. The detecting section 3 irradiates a substrate 5 to be processed, on which the p-Si is formed, with a detection light and inspects the spectral characteristics of reflected light. The operating section 1 examines the wavelength dependence of reflectance and the minimal value of primary variation rate in the wavelength region of 500 nm or thereabout thus determining the optical value. The optical value has a linear relationship to the p-Si crystal grain size which is determines using information held in a memory section 2. Optimal regulation can be performed constantly by measuring the crystal grain size in-line in the process of ELA, or the like.

LEGAL STATUS

[Date of request for examination]	19.05.2000
[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3342387
[Date of registration]	23.08.2002
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] The assessment approach of the semi-conductor film characterized by deducing the diameter of crystal grain of the semi-conductor film based on the reflection factor of the light in the predetermined wavelength region of the semi-conductor film.
[Claim 2] In the assessment approach of the semi-conductor film on a substrate, while investigating beforehand a response with the optical value about the reflection factor of the light in the predetermined wavelength region of two or more semi-conductor film, and the diameter of crystal grain at that time The reflection factor of the light in said predetermined wavelength region of the semi-conductor film which should be evaluated is measured. The assessment approach of the semi-conductor film characterized by determining the diameter of crystal grain of said semi-conductor film which should be evaluated by calculating said optical value about it and collating this optical value with a response with said two or more optical values and diameter of crystal grain which were investigated beforehand.
[Claim 3] Said optical value is the assessment approach of the semi-conductor film according to claim 2 characterized by being the minimal value in the primary rate of change of said reflection factor.
[Claim 4] Said reflection factor is the assessment approach of the semi-conductor film according to claim 2 or 3 which is the reflection factor of the light which carried out incidence at right angles to said semi-conductor film, and is characterized by for said predetermined wavelength region being a unique field of the dependency over the wavelength of said reflection factor or its primary rate of change, and being a unique field nearest to 500nm.
[Claim 5] The Mitsuteru gunner stage for assessment which irradiates the light for assessment at said semi-conductor film in the assessment equipment of the semi-conductor film by which the semi-conductor film on a substrate is evaluated, A reflected light detection means to detect

the reflected light from said semi-conductor film of said light for assessment, An operation means to compute an optical value by calculating the information from said reflected light detection means, The storage means which said optical value and the diameter value of crystal grain were made to correspond, and held them about two or more semi-conductor film of the same kind beforehand, Assessment equipment of the semi-conductor film characterized by having an assessment means to choose from said storage means the diameter value [/ based on the optical value computed with said operation means] of crystal grain, and to determine the diameter value of crystal grain of said semi-conductor film.
[Claim 6] Said operation means computes an optical value based on the information from said reflected light detection means from the relation between the wavelength of the light in the predetermined wavelength region of said semi-conductor film, and the value about a reflection factor. Said storage means Assessment equipment of the semi-conductor film according to claim 5 characterized by making the optical value beforehand computed about two or more semi-conductor film of the same kind from the relation between the wavelength of the light in said predetermined wavelength region, and the value about a reflection factor, and the diameter value of crystal grain at that time correspond, and holding them.
[Claim 7] Said optical value is assessment equipment of the semi-conductor film according to claim 6 characterized by being the minimal value in the primary rate of change of said reflection factor in the predetermined wavelength region of said semi-conductor film.
[Claim 8] Said reflection factor is assessment equipment of the semi-conductor film given in either of claim 5 to claims 7 which are the reflection factor of the light which carried out incidence at right angles to said semi-conductor film, and are characterized by for said predetermined wavelength region being a unique field of the dependency over the wavelength of a reflection factor or its primary rate of change, and being a unique field nearest to 500nm.
[Claim 9] In the formation approach of the semi-conductor film on a substrate, a response with the optical value about the reflection factor of the light in the predetermined wavelength region of two or more semi-conductor film and the diameter of crystal grain at that time is investigated beforehand. While setting up the optical value used as the threshold for obtaining the desired diameter of crystal grain based on this The formation approach of the semi-conductor film characterized by calculating said optical value about the reflection factor of the light

in said predetermined wavelength region of the formed semi-conductor film, comparing said threshold for this optical value after formation of the semi-conductor film, and judging the quality of said formed semi-conductor film.
[Claim 10] In the formation approach of the semi-conductor film on a substrate, a response with the optical value about the reflection factor of the light in the predetermined wavelength region of two or more semi-conductor film and the diameter of crystal grain at that time is investigated beforehand. The process which sets up beforehand the optical value used as the threshold for obtaining the desired diameter of crystal grain based on this, The process which forms the amorphous semiconductor film, and the process which gives laser annealing to the formed amorphous semiconductor film, and is crystallized on it, The formation approach of the semi-conductor film characterized by calculating said optical value about the reflection factor of the light in said predetermined wavelength region of this crystallized semi-conductor film, comparing said threshold for this optical value, and having the process which judges the quality of said formed semi-conductor film.
[Claim 11] Said optical value is the formation approach of the semi-conductor film according to claim 9 or 10 characterized by being the minimal value in the primary rate of change of said reflection factor.
[Claim 12] Said reflection factor is the formation approach of the semi-conductor film given in either of claim 9 to claims 11 which are the reflection factor of the light which carried out incidence at right angles to said semi-conductor film, and are characterized by for said predetermined wavelength region being a unique field of the dependency over the wavelength of a reflection factor or its primary rate of change, and being a unique field nearest to 500nm.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] About the assessment approach of the semi-conductor film created on the substrate, assessment equipment, and the formation approach, this invention is deducing the diameter of crystal grain of the semi-conductor film by optical observation especially, and relates to the assessment approach of the semi-conductor film which enabled in-line-ization, assessment equipment, and the formation approach.
[0002]
[Description of the Prior Art] By using on a substrate the technique which creates the semi-conductor film, the thin film electric field effect mold transistor (TFT:Thin Film Transistor) used as the switching element of the matrix display section is made to one side of the substrate of the couple which raises the degree of integration of an integrated circuit, and attains large capacity-ization, or pinched liquid crystal in between, and development of mass-producing the liquid crystal display (LCD:Liquid Crystal Display) of the active-matrix mold which makes a high definition animation display possible is performed to it.
[0003] If TFT as can show the property near MOSFET especially produced by the silicon substrate can be formed on an insulating substrate, it becomes possible not only the switching element of the matrix display section of LCD but to make the circumference actuation circuit for forming CMOS on the outskirts and supplying a desired actuation signal level to the matrix display section in one, and the so-called mass production driver built-in [LCD] can be performed.
[0004] Since it becomes unnecessary to perform external [of a driver component] to a liquid crystal panel, the cutback of processes and narrow picture frame-ization of driver built-in [LCD] are attained. Especially, as for narrow-picture-frame-izing, the miniaturization of the product itself is attained in the application of a Personal Digital Assistant in recent years or the monitor of a handicap video camera. As one of the important technical problems in such utilization driver built-in [LCD], the good semi-conductor film may be created at the temperature in the heat-resistant critical range of a substrate on transparence insulating substrates, such as glass. Conventionally, forming TFT on a glass substrate was comparatively performed by low

temperature by the 300 to about 400 degrees C thing for which amorphous substance-like a semi-conductor layer, especially an amorphous silicon (a-Si) are created. However, even if on resistance was high and could apply to the switching device of the matrix display section, by the time such a-SiTFT made it possible to constitute the driver section as which high-speed actuation is required from it, it did not result.
[0005] On the other hand, TFT applicable also to the driver section can be formed by using for a channel layer the polycrystal semi-conductor with which the single crystal grain (grain) of a large number with the particle size of hundreds of A to thousands of A exists in the form where it contacted mutually. CMOS with sufficient rate to obtain dozens to about [hundreds of cm] 2/V.s, and for mobility be larger than a-Si double figures, especially polycrystalline silicon (p-Si), i.e., polish recon, and constitute the driver of LCD is formed.
[0006] In order to create such driver built-in p-SiTFTLCD, it has been the biggest technical problem to form good p-Si of membraneous quality on a glass substrate. Usually, p-Si is formed by the approach of forming membranes directly with the solid phase grown method (SPC) to which crystallization is urged by heat-treating to a-Si formed on the substrate, or reduced pressure CVD. Each of these membrane formation approaches is processings in an elevated temperature of 700 to about 900 degrees C, and the manufacture process of p-SiTFTLCD including such an elevated-temperature process is called an elevated-temperature process. In the elevated-temperature process, expensive substrates, such as heat-resistant high quartz glass, required as a substrate, and cost was high.
[0007] For this reason, for some time, the applicant has been developing the approach of the highest also making temperature of a process about 600 degrees C or less, and enabling adoption of a cheap alkali-free-glass substrate etc. as a substrate, in order to lower cost. The manufacture process of p-SiTFTLCD which suppressed such all processes below to the critical temperature of the thermal resistance of a substrate is called a low-temperature process.
[0008] A low-temperature process is giving an excimer laser to a-Si, and became possible by excimer laser annealing (ELA) which stimulates crystallization and creates p-Si. Although an excimer laser is ultraviolet radiation generated in case the excimer made into the excitation state returns to a ground state, by ELA, it processes the configuration of a laser beam according to predetermined optical system, and is irradiated at the non-processing film. Thereby, heat energy is given especially on the surface of a-Si, at the temperature below the heat-resistant critical temperature of a substrate, crystallization is

performed and p-Si is formed.
[0009]
[Problem(s) to be Solved by the Invention] In ELA, it has been main technical problems to solve the problem of the optimal setting out of the laser power and dispersion of exposure laser energy. As the relation between exposure laser energy and the diameter of crystal grain of p-Si (grain size) is shown in drawing 13 , grain size also becomes large as energy imparted becomes large, but if a certain point exceeds a certain point, grain size will become small rapidly and it will become microcrystal-ization, i.e., micro crystal. Therefore, in order to obtain more than grain size (GM) big enough, the power of the laser light source must be set up the optimal between Minimum Ed and an upper limit Eu, and it is necessary to always manage ELA based on the relation of drawing 13 .
[0010] especially -- degradation of a laser medium -- following -- power setting out of equipment -- actually -- a ratio -- if a gap with the effective energy irradiated by the processing film becomes large -- drawing 13 -- following -- the grain size of p-Si -- desired value -- small -- **********. Moreover, in ELA equipment, the laser light emitted in the source of laser oscillation passes long-distance optical system, in order to operate orthopedically in the configuration of having been suitable for predetermined laser annealing and that it does not irradiate, but if optical system is polluted in this case even when it is slight by moisture, a foreign matter, etc., it will cause lowering of effective energy too.
[0011] Furthermore, dispersion in effective exposure energy also poses a problem. That is, if dispersion in exposure reinforcement has arisen in the exposure field of a laser beam, it will pose a problem that grain size does not become large enough in the field corresponding to the part from which exposure energy separated from the optimal range of drawing 13 . As the assessment approach of the grain size of conventional p-Si, although there is SEKOETCHI, the substrate which evaluated the film by this approach cannot be used as a product, but can only perform guessing assessment of other substrates.
[0012] This inventions are the approach an in-line monitor estimates the p-Si film of this ** directly for the purpose of solving the problem to which it comes from exposure laser energy varying, and a thing which offers the formation approach and formation equipment further.
[0013]
[Means for Solving the Problem] This invention is the configuration of being made in order to attain this object, and deducing the diameter of

crystal grain of the semi-conductor film based on the reflection factor of the light in the predetermined wavelength region of the semi-conductor film. Furthermore, in the assessment approach of the semi-conductor film on a substrate, while investigating beforehand a response with the optical value about the reflection factor of the light in the predetermined wavelength region of two or more semi-conductor film, and the diameter of crystal grain at that time It is the configuration of determining the diameter of crystal grain of said semi-conductor film which should be evaluated, by measuring the reflection factor of the light in said predetermined wavelength region of the semi-conductor film which should be evaluated, calculating said optical value about it, and collating this optical value with a response with said two or more optical values and diameter of crystal grain which were investigated beforehand.
[0014] Thereby, the diameter of crystal grain can be evaluated, without destroying the semi-conductor film. Moreover, this invention is set to the assessment equipment of the semi-conductor film by which the semi-conductor film on a substrate is evaluated. The Mitsuteru gunner stage for assessment which irradiates the light for assessment at said semi-conductor film, and a reflected light detection means to detect the reflected light from said semi-conductor film of said light for assessment, An operation means to compute an optical value by calculating the information from said reflected light detection means, The storage means which said optical value and the diameter value of crystal grain were made to correspond, and held them about two or more semi-conductor film of the same kind beforehand, It is the configuration of having an assessment means to choose from said storage means the diameter value [/ based on the optical value computed with said operation means] of crystal grain, and to determine the diameter value of crystal grain of said semi-conductor film.
[0015] Said especially operation means computes an optical value based on the information from said reflected light detection means from the relation between the wavelength of the light in the predetermined wavelength region of said semi-conductor film, and the value about a reflection factor. Said storage means It is the configuration of making the optical value beforehand computed about two or more semi-conductor film of the same kind from the relation between the wavelength of the light in said predetermined wavelength region, and the value about a reflection factor, and the diameter value of crystal grain at that time corresponding, and holding them.
[0016] Since the diameter of crystal grain can be evaluated by this,

without destroying the semi-conductor film, the diameter of crystal grain can be investigated in a manufacture process. Moreover, in the formation approach of the semi-conductor film on a substrate, a response with the optical value about the reflection factor of the light in the predetermined wavelength region of two or more semi-conductor film and the diameter of crystal grain at that time is investigated beforehand. While setting up the optical value used as the threshold for obtaining the desired diameter of crystal grain based on this It is the configuration of calculating said optical value about the reflection factor of the light in said predetermined wavelength region of the formed semi-conductor film, comparing said threshold for this optical value after formation of the semi-conductor film, and judging the quality of said formed semi-conductor film.

[0017] Furthermore, in the formation approach of the semi-conductor film on a substrate, a response with the optical value about the reflection factor of the light in the predetermined wavelength region of two or more semi-conductor film and the diameter of crystal grain at that time is investigated beforehand. The process which sets up beforehand the optical value used as the threshold for obtaining the desired diameter of crystal grain based on this, The process which forms the amorphous semiconductor film, and the process which gives laser annealing to the formed amorphous semiconductor film, and is crystallized on it, It is the configuration of having the process which calculates said optical value about the reflection factor of the light in said predetermined wavelength region of this crystallized semi-conductor film, compares said threshold for this optical value, and judges the quality of said formed semi-conductor film.

[0018] Since the diameter of crystal grain can be evaluated by this, without destroying the semi-conductor film, in the middle of a manufacture process, a defective can be removed and cost is reduced.

[0019]

[Embodiment of the Invention] Drawing 1 to drawing 4 is related curvilinear drawing which measured the wavelength dependency (phase comparison) of the reflection factor of the p-Si film formed by giving ELA to the a-Si film. As an optical exposure and lighting equipment, the multichannel spectrometry machine made from the Otsuka electron was used. Moreover, an optical exposure and the reflected light went perpendicularly to the object film. When ELA laser power of drawing 1 is 520mJ(s), drawing 2 is [540mJ(s) and drawing 4 of 530mJ(s) and drawing 3] 550mJ(s) similarly. By comparing these drawings shows the following things. That is, the related curve is presenting the characteristic

configuration near the wavelength of 500nm, and the singularity itself is further dependent also on laser power. Especially, in drawing 1 and drawing 2 , it is a trough. such change of the configuration of the reflection factor curve depending on laser power originates in change of the grain size of the p-Si film -- it thinks.
[0020] Then, the applicant differentiated the reflection factor curve and searched for primary rate of change. Drawing 5 to drawing 8 is the wavelength dependency curve of the primary rate of change of the reflection factor curve of drawing 1 to drawing 4 respectively. The deflection of a rate-of-change curve is large in the form where the singular part of a reflection factor curve was emphasized in near 500nm like drawing 4 from drawing 1 . namely, the singular part of the reflection factor curve in drawing 4 from drawing 1 -- in more detail in the field near [where wavelength becomes large / where it is alike, and it follows and a reflection factor also becomes high] 500nm, the inclination of a reflection factor curve has changed locally -- further There is a place which falls and serves as a trough and the relation of such a wavelength-reflection factor is clearly expressed as the minimum depth as shown by the arrow head in the trough of a rate-of-change curve in drawing 8 from drawing 5 . It has this minimal value and is made to represent with this invention as an optical value which is a value of a proper when ELA is performed under each conditions.
[0021] Drawing 9 is drawing which investigated the relation between the optical value acquired by doing in this way, and the grain size obtained by surveying by SEKOETCHI etc. on the actual p-Si film at that time about many samples. A continuous line is a trend line of these relation. This shows that grain size is large, so that it will be carried out the more if the singular part of the reflection factor curve of drawing 4 is eased from drawing 1 the more an optical value becomes large namely. That is, in these condition range, grain size is changing to the linear to an optical value. Therefore, grain size can be deduced by investigating the rate of change of a reflection factor.
[0022] Although the mechanism does not have such a clear wavelength dependency of a reflection factor or its rate of change about a unique property being shown in a specific wavelength field, depending on whenever [crystal order], the superiority or inferiority of an echo and scattered reflection change, and that in which it appears notably in an above-mentioned wavelength region especially is conjectured. Therefore, the diameter of crystal grain can be deduced from investigating such optical property in inverse operation.
[0023] Here, I hear that the relation between an optical value and laser

energy (grain size) has the description as shown in drawing 10 , and having been traced still more nearly experientially has it. That is, in a certain energy field, an optical value turns into the minimum value and it has relation in which an optical value rises symmetrically on the both sides. And the energy density which takes the minimum value of such an optical value experimentally is from 300 mJ/cm2 to 350 mJ/cm2 generally, and when the laser power in ELA considers that fine adjustment in the range of 400 mJ/cm2 to about two 500 mJ/cm is demanded for an energy density, it turns out that the relation between an optical value and laser power, i.e., grain size, presents a linear configuration mostly.

[0024] Drawing 11 is the block diagram of the assessment equipment concerning the gestalt of operation of this invention. It is the processed substrate with which the semi-conductor film with which operation part and (2) should evaluate (1) and a detecting element and (5) should evaluate the storage section and (3) was formed. As for a detecting element (3), a light emitting device and lighting components, such as a halogen lamp, constitute the coaxial fiber. ELA is given, a processed substrate (5) is crystallized by a-Si formed on the insulating substrate, and p-Si is formed. A detecting element (3) detects that reflected light, and investigates the spectral characteristic while it irradiates the light for detection at this processed substrate (5). This spectral characteristic information is sent to operation part (1). In operation part (1), the wavelength dependency of the reflection factor shown in drawing 4 from drawing 1 is computed, the primary rate of change of the reflection factor shown in drawing 8 from drawing 5 is searched for, further, the minimal value is investigated and an optical value is determined after this. This optical value is sent to the storage section (2). The optical value shown in drawing 9 and the grain size at that time correspond, and are held at the storage section (2). The storage section (2) is the nonvolatile memory by which the value of the grain size which made information based on an optical value the address was held. Therefore, the address is generated based on the optical value sent from operation part (1), and reading appearance of the value of grain size is carried out. Thus, the obtained grain size is determined as grain size of the processed substrate (5). Dispersion in the exposure field of ELA energy is manageable by performing measurement of such grain size by two or more points on a processed substrate (5). Moreover, according to the property of ELA equipment, and the time of equipment, the information held at the storage section (2) can be rewritten, or can also respond also to long-term condition fluctuation

by exchanging memory etc.
[0025] Assessment of the p-Si film in such this invention is performed by measurement of the rate of a light reflex, i.e., lighting of a suitable optical exposure and its reflected light. Therefore, in-line monitoring can become possible, the grain size measurement process concerning this invention can be installed immediately after the formation process of the p-Si film, and ELA can be managed. Drawing 12 is assessment equipment introduced into a manufacture process. (1), (3), and (5) are the same operation part as drawing 11 , a detecting element, and a processed substrate respectively. (4) is the judgment section. The optical value corresponding to the upper limit of the tolerance of the grain size of target p-Si and the optical value corresponding to a minimum are set to the judgment section (4). The optical value sent from operation part (1) is compared with the optical value of these upper limits and a minimum, it is investigated whether the grain size of the processed substrate (5) of this ** is in tolerance, and the quality of the processed substrate (5) is judged. When it judges that a processed substrate (5) is poor, as for the processed substrate (5), migration at degree process is forbidden.
[0026] By thus, the thing for which the assessment process of this invention is installed after an ELA process Measure the grain size just behind ELA and laser radiation energy changes for some reasons [exhausting / contamination of moisture, a foreign matter, and optical system, / of the laser light source]. When grain size does not become large enough, or it stops and cancels ** and manufacture, delivery and the p-Si film are removed at the etching process of the p-Si film, and measures, such as redoing from a membrane formation process again, are taken. Furthermore, by unifying the assessment process of ELA and this invention, the p-Si film is evaluated on a simultaneous target, performing laser radiation, and ELA while always adjusting laser power the optimal becomes possible by feeding back to ELA.
[0027]
[Effect of the Invention] By this invention, since insertion to a production process of the assessment process of the diameter of crystal grain of the semi-conductor film was attained, management of a semi-conductor film formation process can always be performed. Thereby, when the membraneous quality of the semi-conductor film immediately after formation comes outside tolerance, ** and manufacture can be stopped and a defective can be discovered in an early phase. For this reason, excessive cost is reduced and the yield improves. Moreover, film assessment is performed in parallel with a production process, and since

it is always finely tuned by the optimal conditions by reflecting this in a semi-conductor film formation process, a semiconductor device with a good property is manufactured.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is related drawing which measured the wavelength dependency of the reflection factor of the p-Si film in this invention.

[Drawing 2] It is related drawing which measured the wavelength dependency of the reflection factor of the p-Si film in this invention.

[Drawing 3] It is related drawing which measured the wavelength dependency of the reflection factor of the p-Si film in this invention.

[Drawing 4] It is related drawing which measured the wavelength dependency of the reflection factor of the p-Si film in this invention.

[Drawing 5] It is related drawing which searched for primary rate of change from the curve of the wavelength dependency of the reflection factor in drawing 1 .

[Drawing 6] It is related drawing which searched for the primary rate of change of the curve of the wavelength dependency of the reflection factor in drawing 2 .

[Drawing 7] It is related drawing which searched for the primary rate of change of the curve of the wavelength dependency of the reflection factor in drawing 3 .

[Drawing 8] It is related drawing which searched for the primary rate of change of the curve of the wavelength dependency of the reflection factor in drawing 4 .

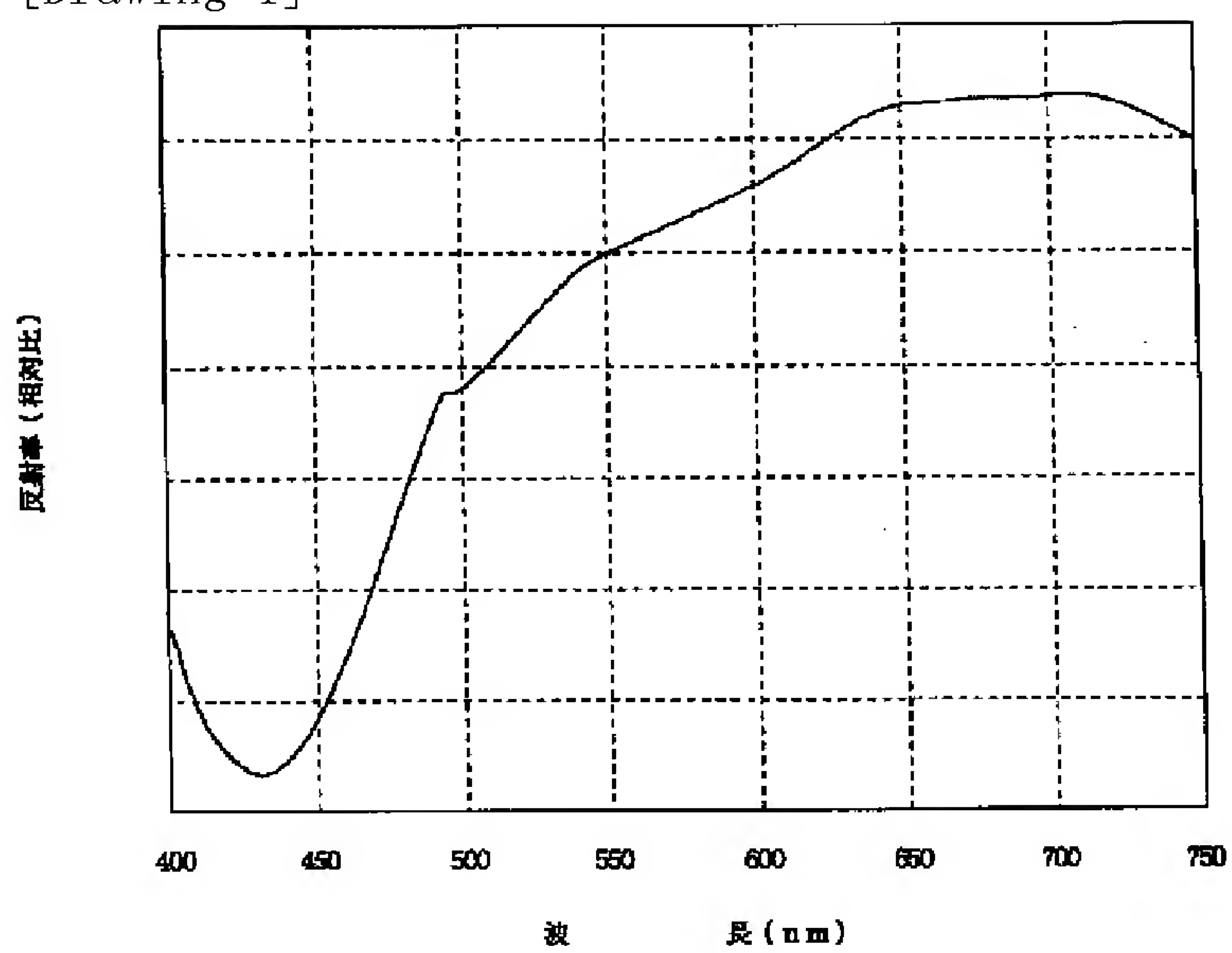
[Drawing 9] It is related drawing of the minimal value of primary rate of change, and the grain size of the p-Si film.

[Drawing 10] It is related drawing of laser energy and the minimal value of primary rate of change.
[Drawing 11] It is the block diagram of the assessment equipment of the semi-conductor film concerning the gestalt of operation of this invention.
[Drawing 12] It is the block diagram of the formation equipment of the semi-conductor film concerning the gestalt of operation of this invention.
[Drawing 13] It is related drawing of exposure laser energy and grain size.
[Description of Notations]
1 Operation Part
2 Storage Section
3 Detecting Element
4 Judgment Section
5 Processed Substrate

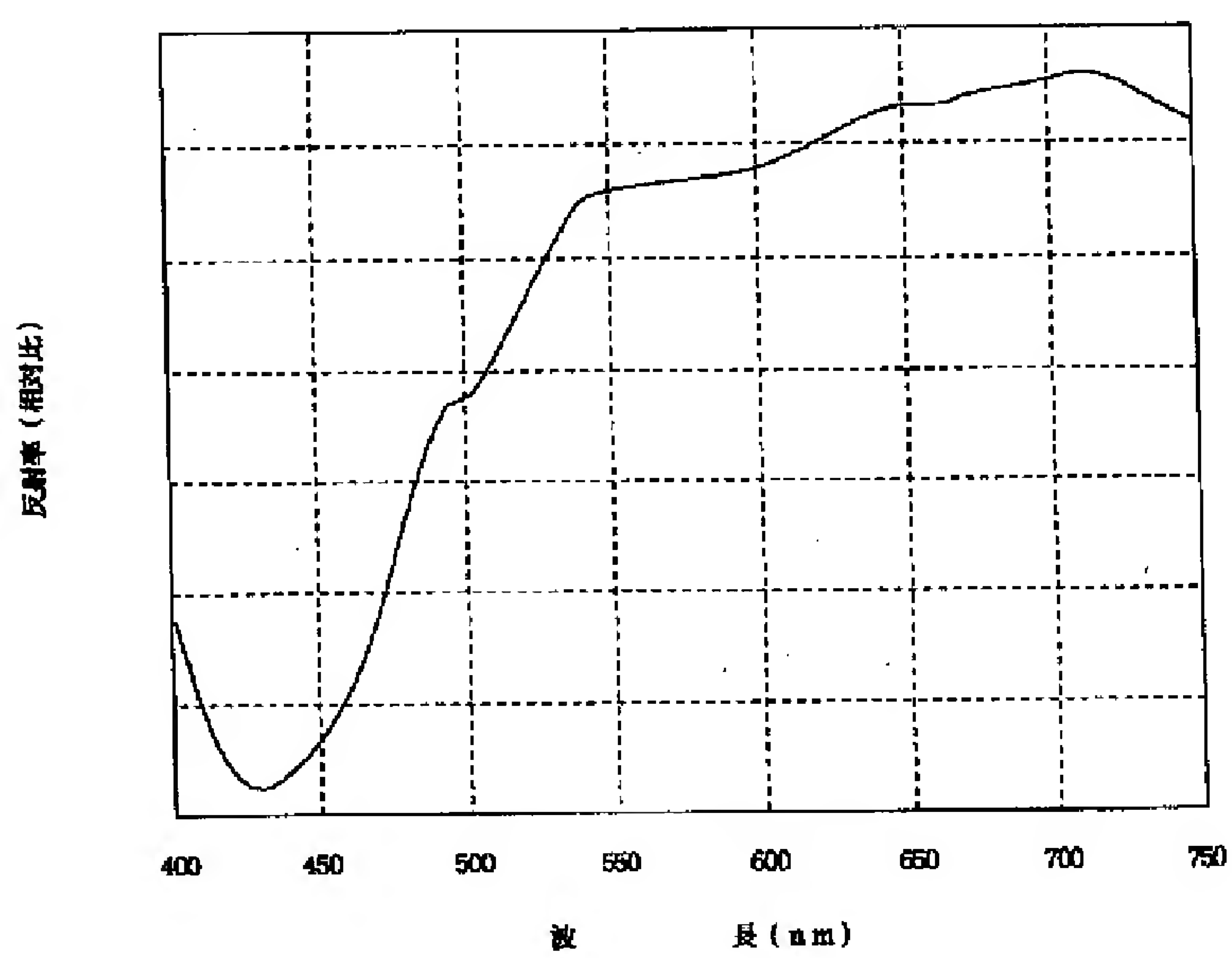
[Translation done.]

DRAWINGS

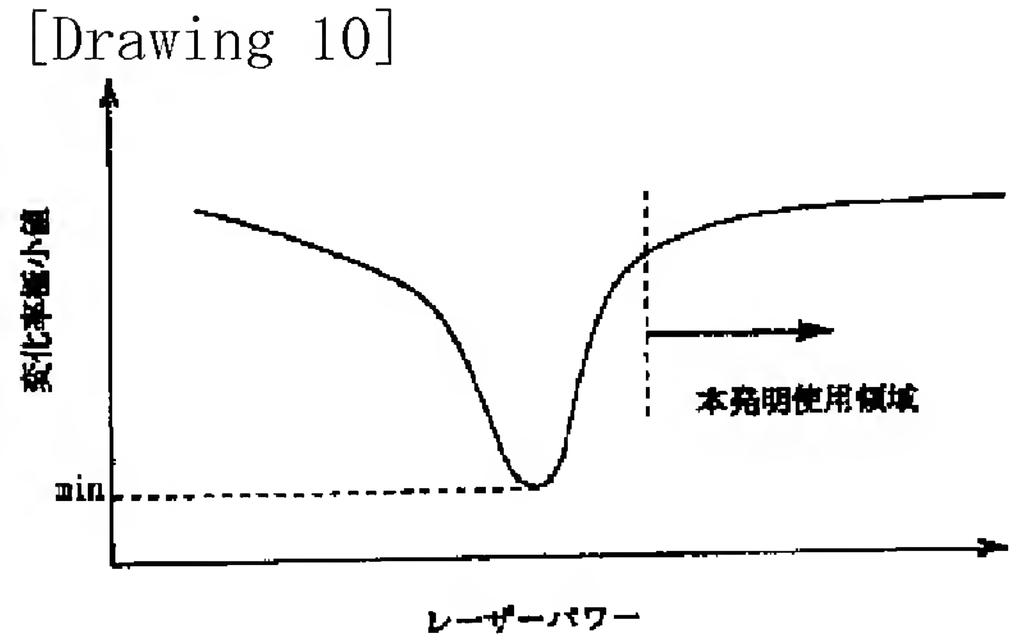
[Drawing 1]



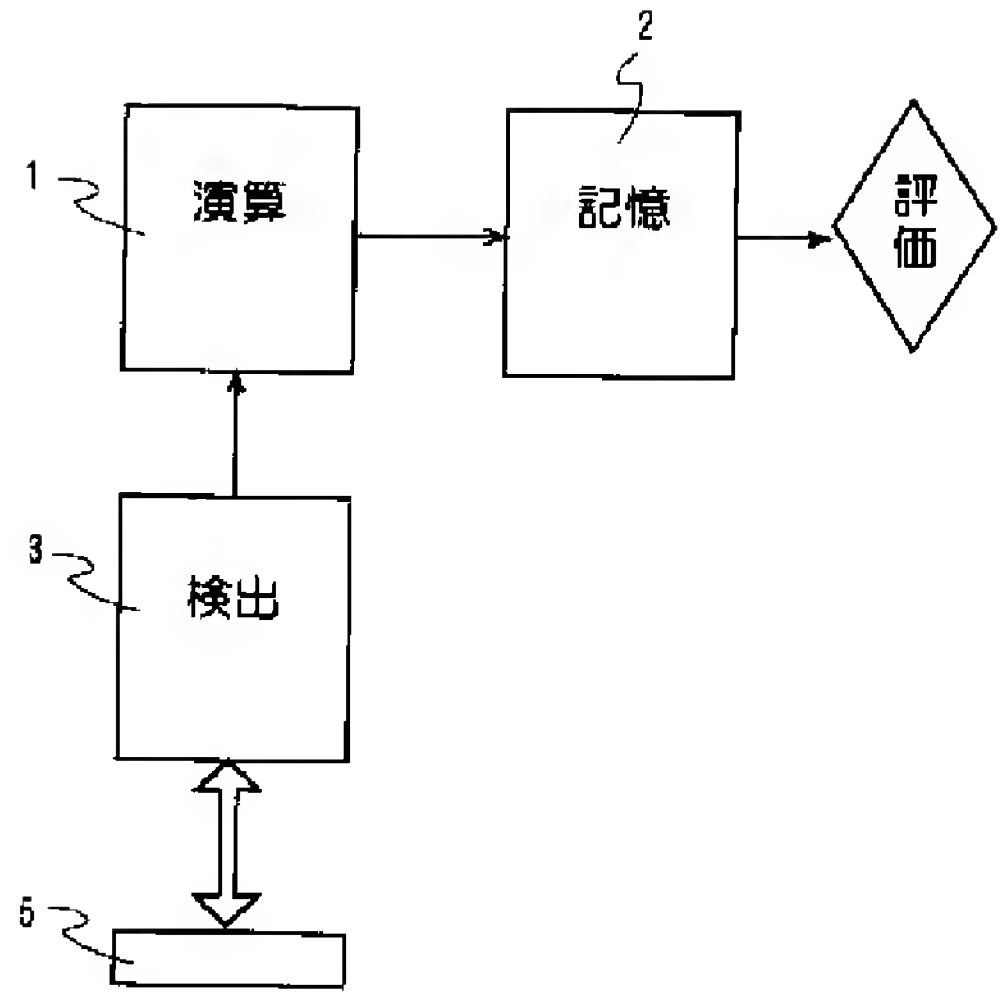
[Drawing 2]



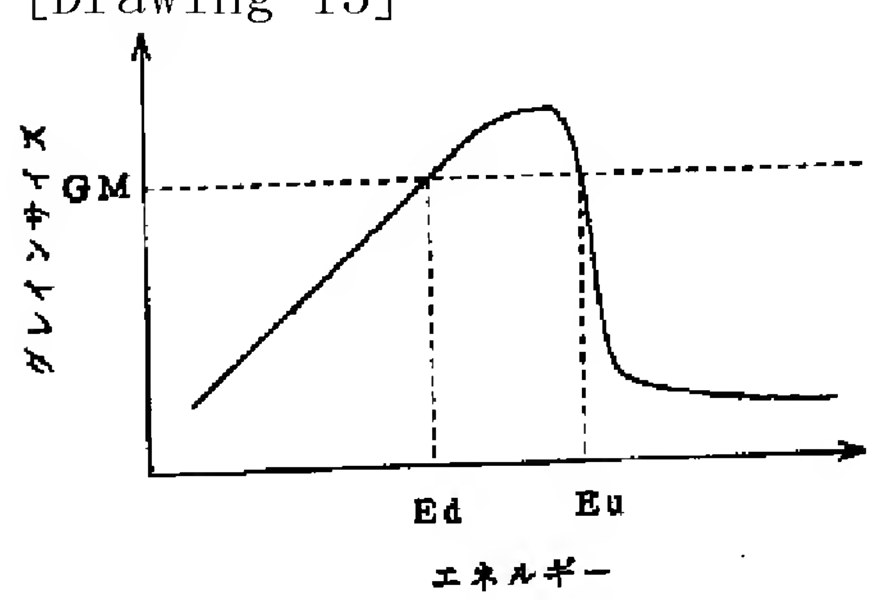
[Drawing 10]



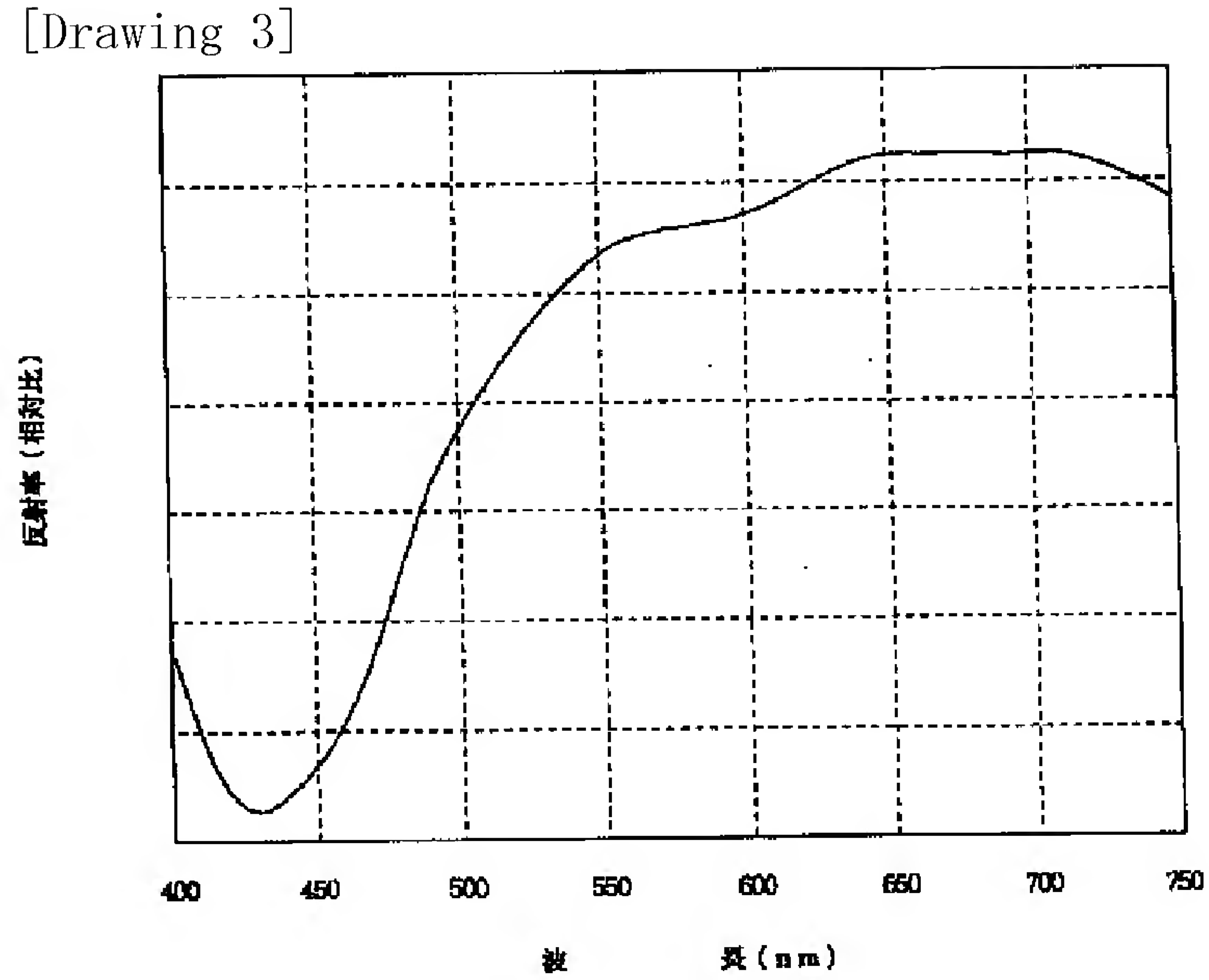
[Drawing 11]



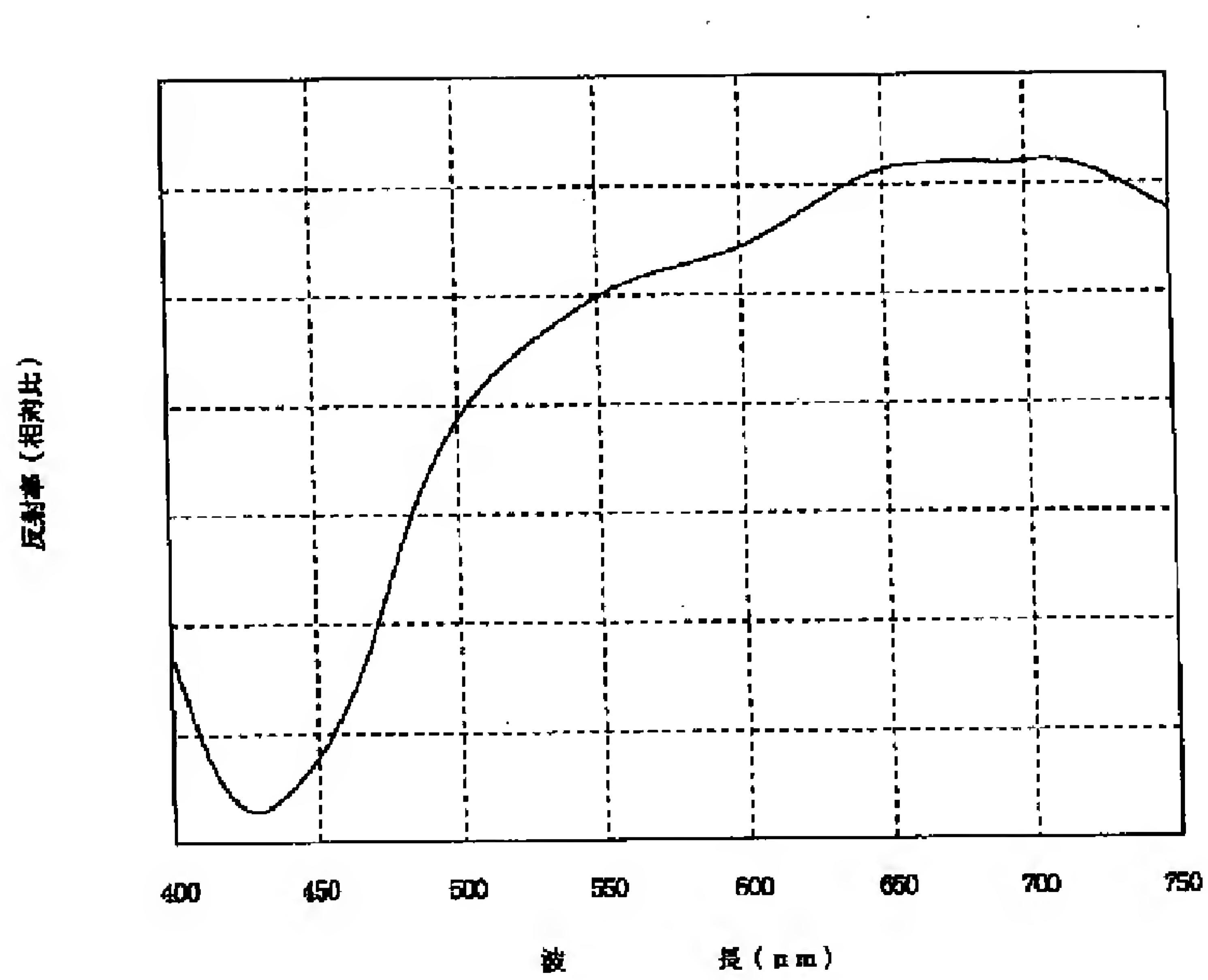
[Drawing 13]



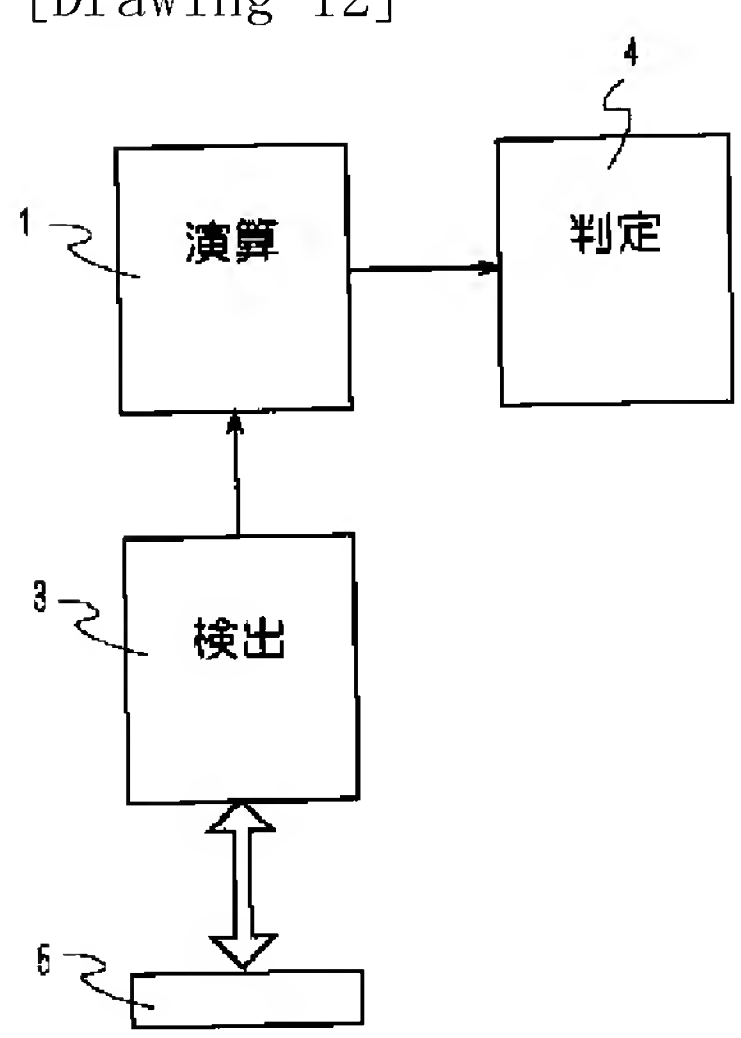
[Drawing 3]



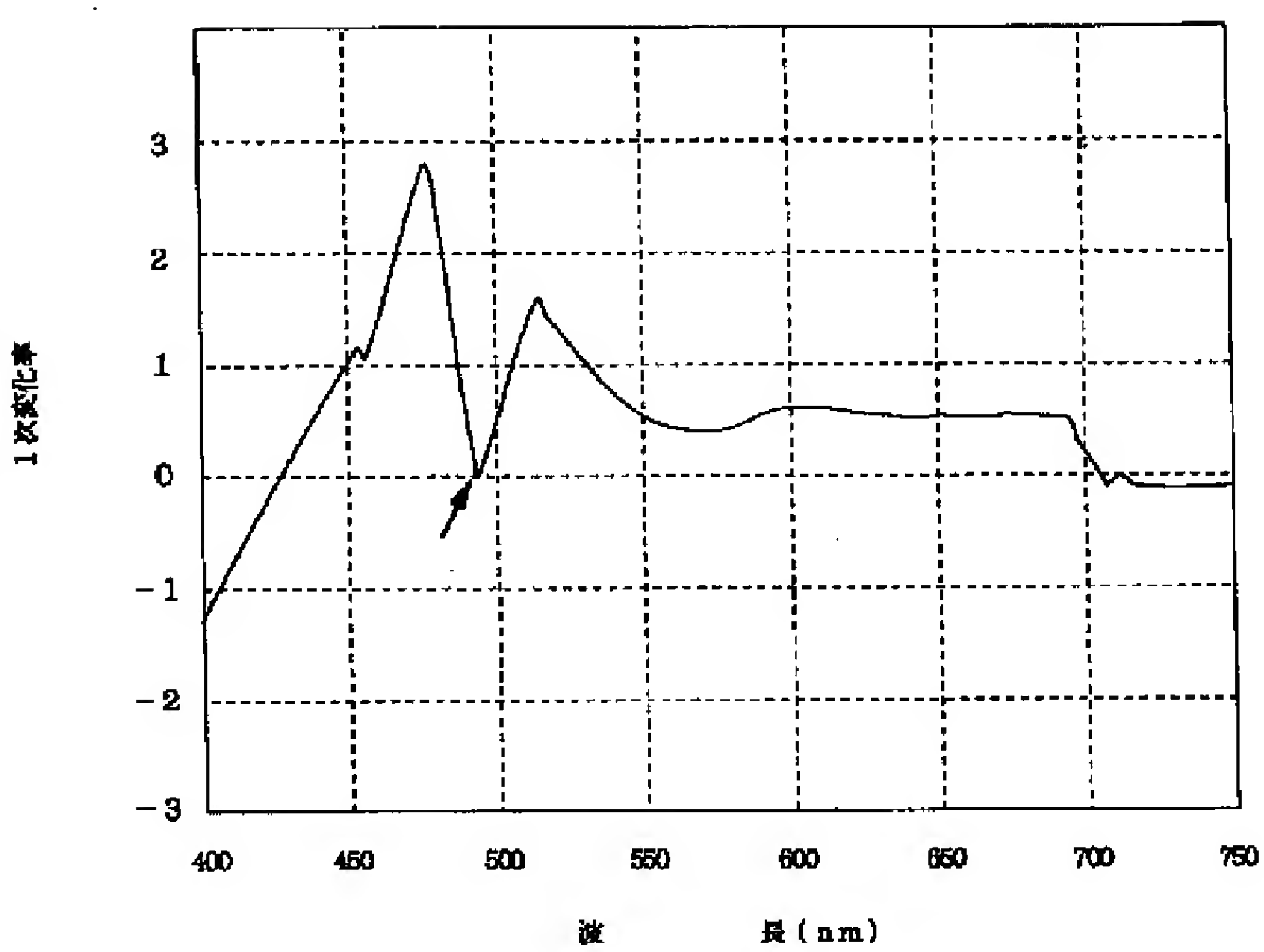
[Drawing 4]



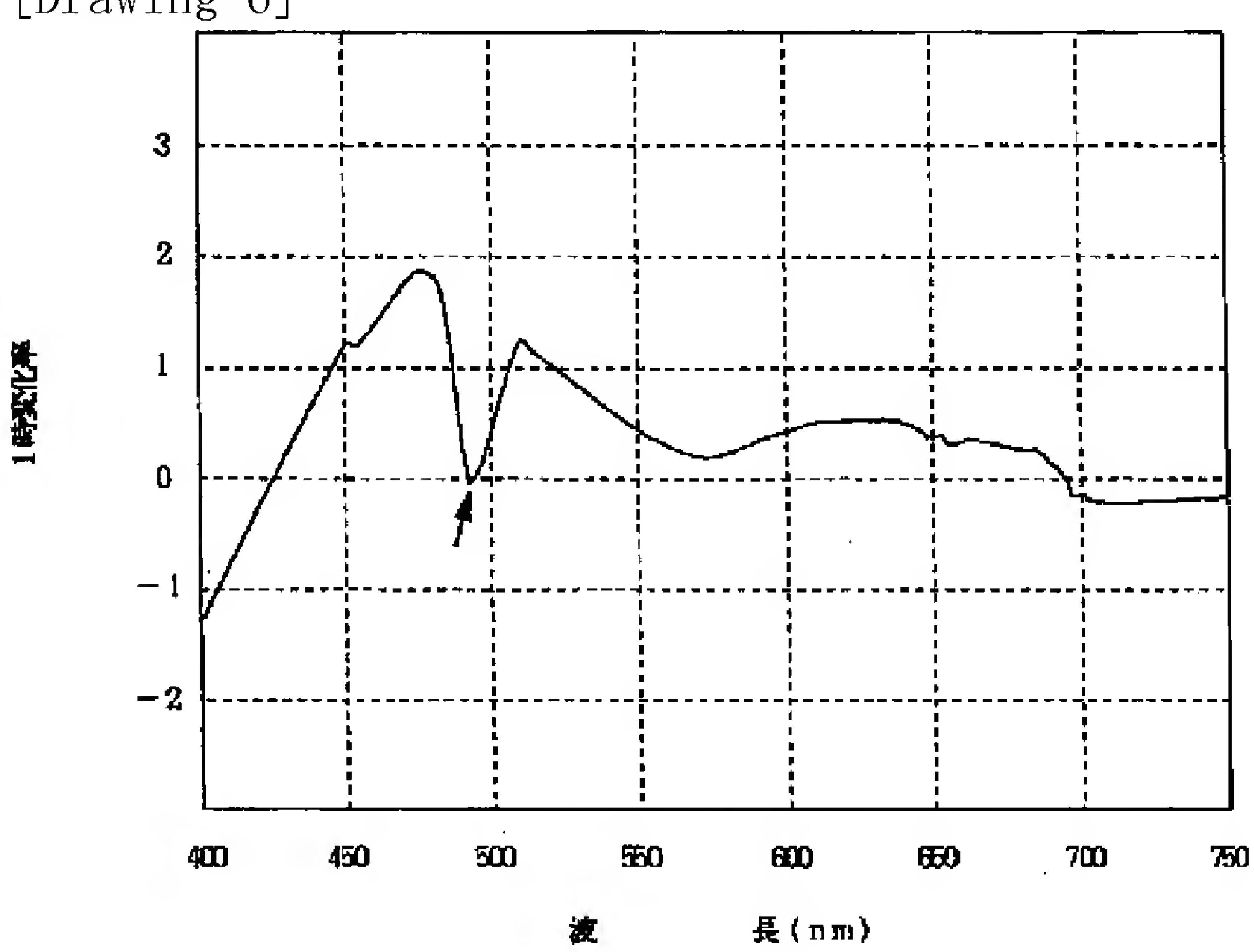
[Drawing 12]



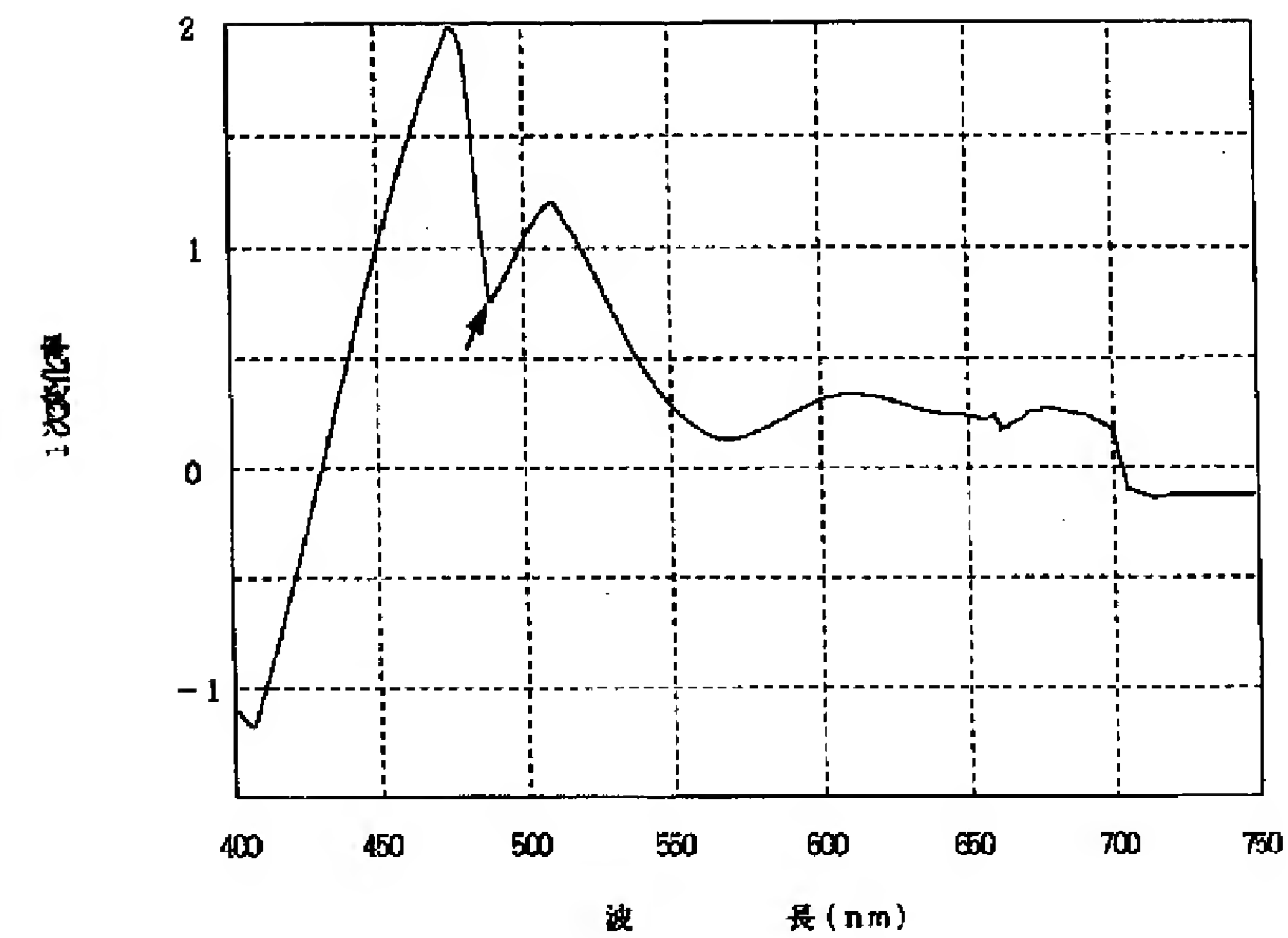
[Drawing 5]



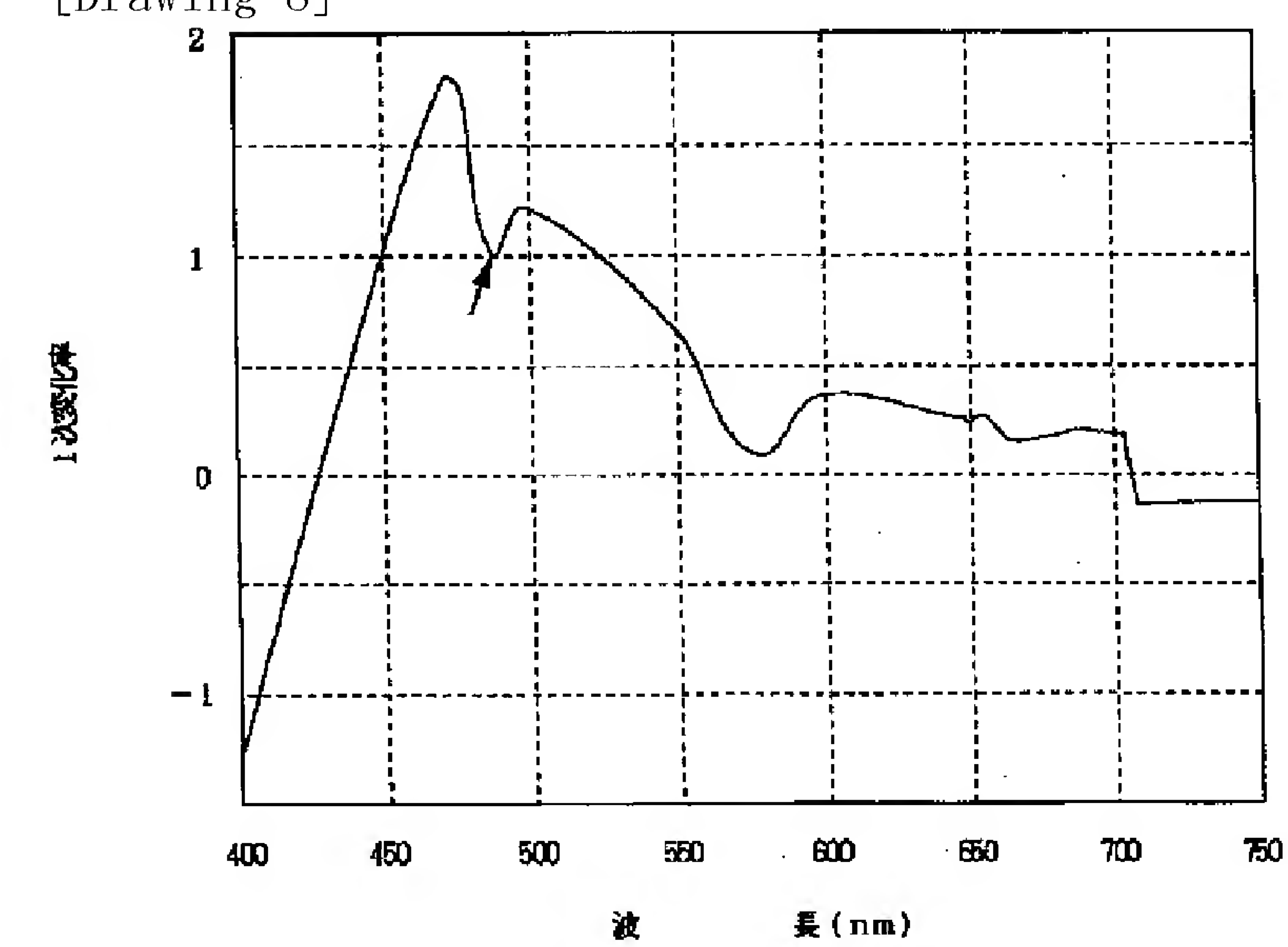
[Drawing 6]



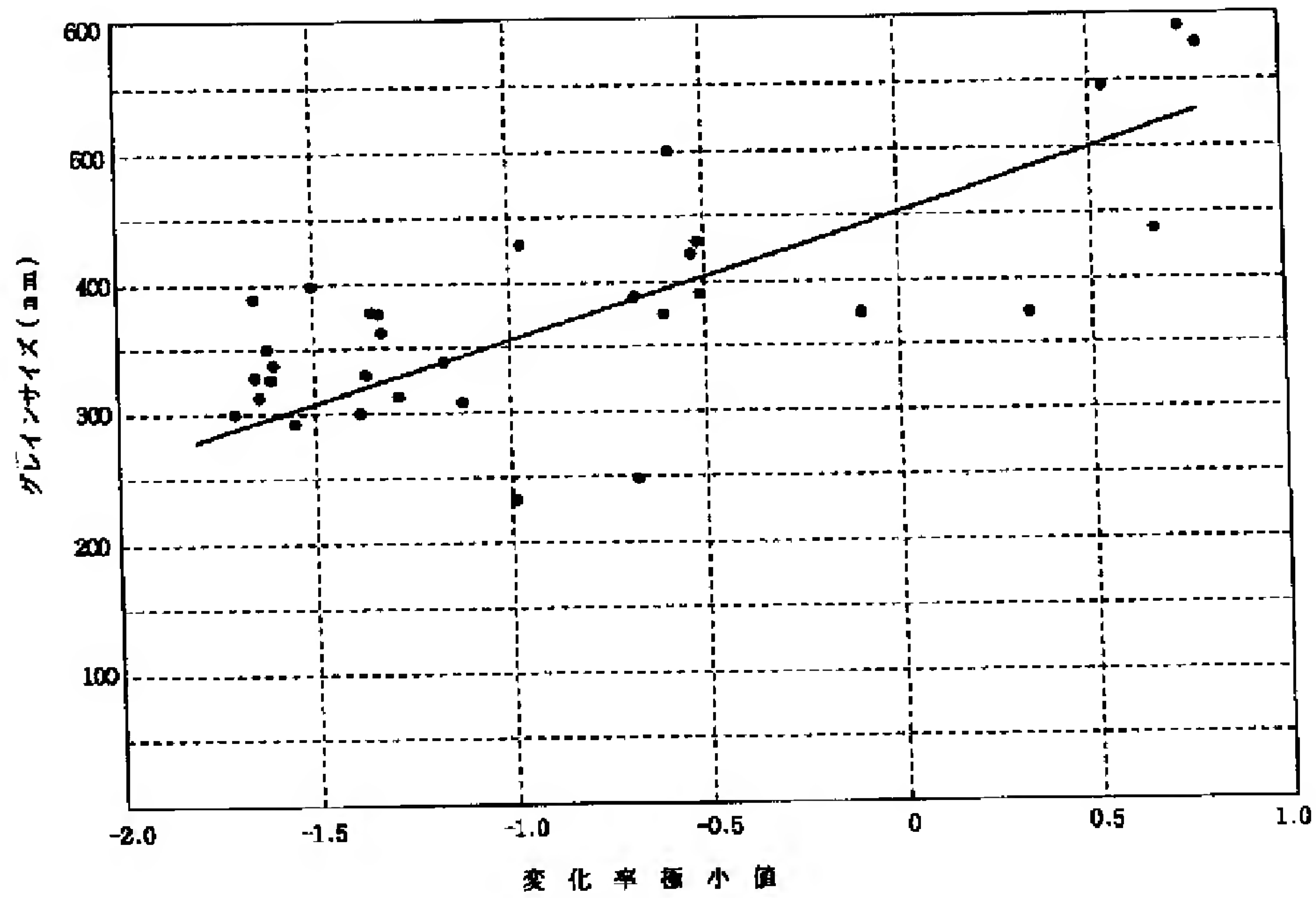
[Drawing 7]



[Drawing 8]



[Drawing 9]



[Translation done.]